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STATE HORTICULTURAL COMMISSION
ELLWOOD COOPER, Commissioner

UNIV. OF MICH

APR 8 1906

ENTOMOLOGY IN OUTLINE

Compiled for the Use of County Horticultural
Commissioners and Fruit-Growers

BY
JOHN ISAAC



SACRAMENTO

W. W. SHANNON

SUPERINTENDENT STATE PRINTING

1906



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REPRESENTATIVES OF THE SEVEN PRINCIPAL ORDERS OF INSECTS

PLATE I.

REPRESENTATIVES OF THE SEVEN PRINCIPAL ORDERS OF INSECTS.

1. Orthoptera—*Hippiscus rugosus*.
2. Diptera—*Exoprosopa caliptera*.
3. Hemiptera—*Rasahus biguttatus*.
4. Lepidoptera—*Papilio turnus*.
5. Coleoptera—*Buprestis*.
6. Hymenoptera—*Vespa germanica*.
7. Neuroptera—*Polystæchotes punctatus*.

All natural size.

PLATE I

THE GEOGRAPHICAL DISTRIBUTION OF THE SEVEN LEPIDOPTERAN SPECIES OF THE GENUS *Parasitochloa*

1. *Parasitochloa* - *Parasitochloa*
2. *Parasitochloa* - *Parasitochloa*
3. *Parasitochloa* - *Parasitochloa*
4. *Parasitochloa* - *Parasitochloa*
5. *Parasitochloa* - *Parasitochloa*
6. *Parasitochloa* - *Parasitochloa*
7. *Parasitochloa* - *Parasitochloa*

FIGURE 1

STATE HORTICULTURAL COMMISSION

ELLWOOD COOPER, Commissioner

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CALIFORNIA STATE COMMISSION OF HORTICULTURE.

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ACKNOWLEDGMENT.

To P. Blakiston's Sons & Co., Philadelphia, we are indebted for the use of the cuts numbered below, which appeared in the excellent work by Professor J. W. Folsom, entitled "Entomology, with Special Reference to its Biological and Economic Aspects": Cuts numbered Fig. 1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 38, 41, 56, 57, 59, 60, 68, 80, 84, 87, 110.

ENTOMOLOGY IN OUTLINE.

Arranged for Horticultural Commissioners, Fruit-Growers, and Farmers.

By JOHN ISAAC.

Some simple work, which shall present, in plain, every-day language, information about the insect world, has long been desired by our County Horticultural Commissioners and fruit-growers. As a rule, these men are not scientific entomologists, nor do they need be, but, at the same time, it is necessary that they should know something of insects and their modes of living, and be able to distinguish between insect friends and enemies, in order that they may protect the one and destroy the other.

It is much to be able to tell to what order an insect belongs, more to know to what family in that order it belongs, and this is as far as the average commissioner or orchardist can hope to go; to go farther and trace it to genera and species is the work of the trained entomologist, and is a life work alone for any man.

It is the desire of the writer to place such knowledge before his readers, in the simplest manner, divested as far as possible of all scientific and technical terms. Those who desire more can acquire it from the scientific text-books. We do not offer this as a scientific dissertation on entomology, nor as giving, by any means, all that is known of that science, but simply as an introduction to every-day men of the more general facts which they should know in the pursuit of their calling for the benefit of their constituents.

SYSTEM IN NATURE.

Success in any pursuit depends upon system, and this is essentially true of the study of any branch of natural history. As we gaze around us upon the material world, we behold a conglomerate mass of life that may astonish, or even oppress, us with its multitudinous forms, but until we can take each individual object and trace it down to its proper place in the order of nature, it has no meaning for us. To accomplish this, the natural sciences,—geology, botany, biology,—have been established, and these again have been subdivided, until every object can be assigned to its proper place and its life and peculiarities known and described. There is no field in which subdivision has been called out

so fully as in the natural sciences; as a result, we have a perfect system of classification, which enables us to recognize and study with the greatest ease any natural object which comes under our observation.

The earth naturally is divided into three great kingdoms—the mineral, the vegetable, and the animal. The mineral is the first and the oldest. Without it, neither of the others could exist. In fact, the vegetable and animal kingdoms may be considered as subordinate to the mineral and springing from it, for the material part of all vegetable and animal is mineral, and so soon as the vital element has departed, they restore to the mineral what they have borrowed from it. The vegetable kingdom comes next in order, for there could be no animal life until there was abundant vegetable life to support it.

Our business now is only with the animal kingdom, and with only one branch, though a very important branch, of that. This kingdom has been divided into two subkingdoms, known as the Vertebrata and the Invertebrata. The Vertebrata include all animals having a

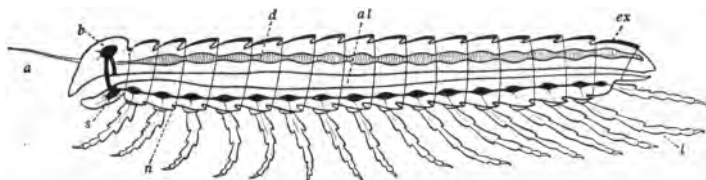


FIG. 1. Diagram to express the fundamental structure of an Arthropod. *a*, antenna; *al*, alimentary canal; *b*, brain; *d*, dorsal vessel; *ex*, exoskeleton; *l*, limb; *n*, nerve chain; *s*, subesophageal ganglion. (After Schmeil.)

backbone, as mammals, birds, fishes, and reptiles. The Invertebrata cover all that class of animals which have no backbone, or vertebra, and this is by far the larger and more important branch of the animal kingdom, as it includes a vastly greater number of forms and is more numerous in its individuals than is the other.

The Invertebrata have been divided into eight branches, as follows:

Protozoa, which includes the lowest forms of animal life. These are single-celled animals, many or most of them exceedingly minute, or even microscopic in size, and without definite shape. In most cases reproduction is effected by subdivision.

Poriferata, which are animals a stage higher in their development, and including sponges and kindred forms.

Cœlenterata, in which we find the jelly-fishes and corals.

Echinodermata, which includes the sea-eggs or sea-urchins and the star-fishes.

Vermes, which covers the various forms of worms, leeches, and their kindred.

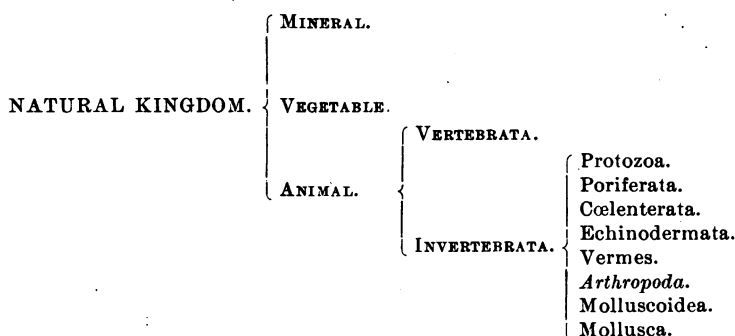
Molluscoidea. This is confined to two groups of aquatic animals, the Brachipoda and Polyzoa. The first of these was formerly placed in the

Mollusca, and the latter in the Zoöphytes, but they were found to be more nearly related to each other than to the branches in which they had been included and the Molluscoidea was erected for them.

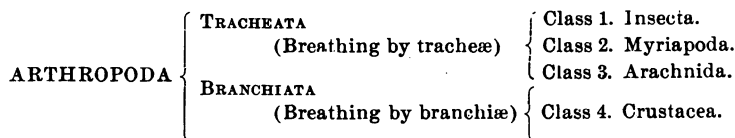
Mollusca embraces what is commonly known as shell-fish, while the land forms are represented by snails and slugs.

Arthropoda. This is the branch in which we are especially interested. It is separated into two divisions: the Tracheata and Branchiata. The Tracheata are aerial animals, which derive their oxygen from the air by tracheæ or tubes. This division includes insects, myriapods, centipedes, thousand-legged worms, etc., and the Arachnida (spiders, scorpions, etc.). The Branchiata are aquatic animals, which breathe through branchiæ, or gills, or sometimes through the whole surface of the body. There is but one class under this division, the Crustacea, including crabs, lobsters, shrimps, etc. The common sow-bug is a land form of this branch.

Having now reached our subject, and traced the insect group down to its proper place, we will proceed to deal with this class by itself. The following diagram will present to the reader the position of the class *Insecta* in its relation with creation:



The branch *Arthropoda* may be presented in tabular form, as follows:



Conspicuous examples of the Crustacea are lobsters, crawfish, crabs, shrimps, etc., while the terrestrial forms are represented by the sow-bugs, which are so common in damp locations, and which are frequently mistaken by young entomologists for members of the Myriapoda.

Class 1, *Insecta*, is the only one with which we have any immediate concern, although it is necessary to understand something of the other air-breathing classes, which are so nearly related to the insects, and

among which we find forms beneficial or injurious to our fields and orchards.

The *Crustacea* are of little interest to us, except as members of the Arthropoda. The members of this class are chiefly aquatic, and are grouped with the insects because the general structure is the same.

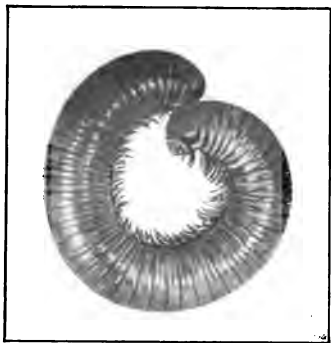


FIG. 2. A diplopod (*Spiroboleus marginatus*).
Natural size.

The distinguishing feature of the Arthropoda is that the bodies are segmented; that is, they are composed of a series of rings fitted into each other or articulated. In some classifications this class is designated as the Articulata, and is made to include the Vermes, or worms, which are also segmented. The latter, however, properly belong in a class by themselves, and the Arthropoda may be stated to include all segmented or ringed animals with legs.

It is by far the most important of all the subkingdoms, and includes a larger number of species than all the others combined. The Crustacea fit the description above and are naturally included in the same subkingdom with the insects.

The *Myriapoda* come more directly under our view. They are land animals and, in some cases, are very injurious to crops. The centi-

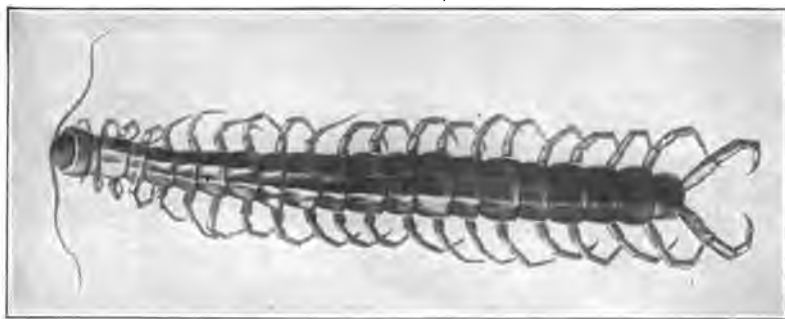


FIG. 3. A centipede (*Scolopendra heros*). About two thirds the maximum length.

pedes and millipedes are included in this class. Some of these are very minute and others attain great size. One of the smaller of the centipedes sometimes appears in vast numbers in damp locations and does great damage to young plants.

The *Arachnida* include the whole of the spider family. They are distinguished from insects by the fact that their members generally have eight legs, while insects have but six. They pass through no

metamorphosis, the young resembling the matured members in everything except size, and they have no antennæ. Some of our greatest orchard pests are found in this group, among them being the red spider

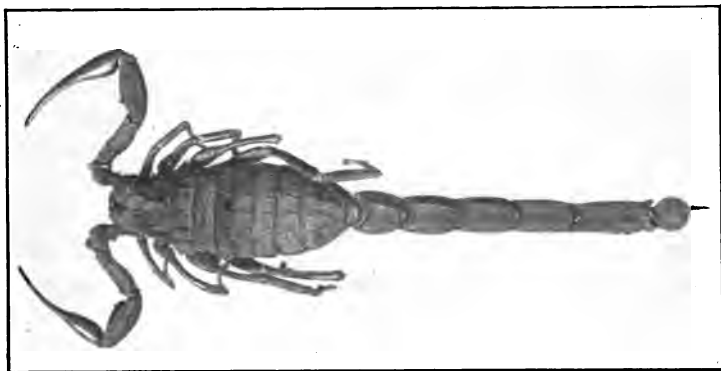


FIG. 4. A scorpion (*Buthus*). Natural size.

and various mites; the ticks, which so trouble our poultry and live stock, also belong to this class, as do the phytopti, which infest our pear trees and grapevines. The disease known as the "itch" among men is also caused by a member of this family, called the itch mite. Some of the mites, during the larval or undeveloped stage, have six legs, acquiring their entire complement of eight only when fully developed, and the phytopti have but four legs at any period of their existence. These, however, are exceptions to the rule—that members of this class have eight legs. It will be observed from the above that some of our most troublesome pests are found in this class, but there are also some that are beneficial. In fact, very many of the spiders, which are generally predaceous, perform a beneficial work in keeping down injurious species.

CLASSIFICATION.

In order to place properly an insect or other natural object, a system of classification is necessary. As stated before, we have three great kingdoms. All objects have distinguishing characteristics which place them naturally in one or the other of these, and we know at a glance to which

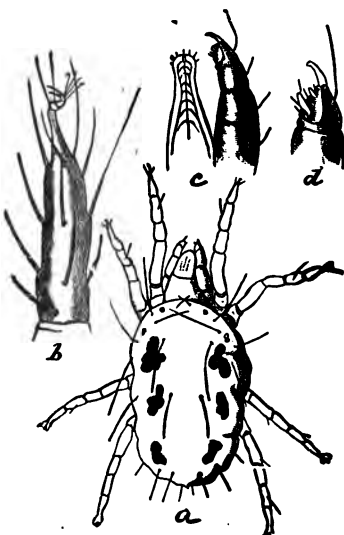


FIG. 5. Six-spotted mite (*Tetranychus maculata*). *a*, insect, much enlarged; *b*, tarsus; *c*, rostrum and palpus, still more enlarged; *d*, tip of palpus, still more enlarged.

they belong. Everything that lives, breathes, walks, flies, or swims, everything with fur, feathers, or scales, we know belongs to the animal kingdom. But among animals there are great dissimilarities. As stated, one great portion has an articulated backbone or vertebra, and another, and more important class, has none; so our great animal kingdom branches off into two forks, and these are known as subkingdoms. It is still easy to tell to which of these an animal belongs, for every child can tell at a glance whether it has a backbone or not. So far our task is easy, but there are great points of difference, even among backbone and non-backbone animals. The snake, the bird, and the horse all have backbones and, therefore, all belong to the subkingdom Vertebrata, but they have little else in common, so the Vertebrata are again divided into four classes—mammalia, birds, reptiles, and fishes. Each of these again is divided and subdivided according to well-marked peculiarities common to the whole group, until we get down to the species and the individual. This has been explained in the preceding pages, where we have followed the insect down to its place in the animal kingdom, through the Invertebrata, Arthropoda, and Tracheata. So by means of the following stages we can trace an insect down to its natural place:

Kingdom,
Subkingdom,
Branch,
Class,
Order,
Family,
Genus,
Species,
Individual.

To illustrate, we will take our common swallow-tailed butterfly, and work it down to its final place:

Kingdom	= Animal.
Subkingdom	= Invertebrata.
<i>Papilion</i> Branch	= Arthropoda.
Class	= Hexapoda.
Order	= Lepidoptera.
Genus	= Papilio.
Species	= Rutulus.

All of the species Rutulus are alike. Where there are slight variations, these are not fixed, but found only in the individuals. With different members of the genus Papilio, however, there are very distinct differences, yet all have a general similarity, enough to group them in one genus, so all the members of the genus Papilio have characters in

common with all other butterflies and are grouped with them in the order Lepidoptera.

Really, the first four of these stages concern us but little. We all know to what kingdom an animal belongs, equally to what subkingdom. Neither the branch nor the class will bother us much, although the knowledge of very many people stops at this and they confound many of the other members of the Arthropoda with the class Hexapoda, and regard spiders, centipedes, scorpions, and, in fact, all things that creep or crawl, and are not beasts, birds, reptiles, or fishes, with insects. It is after we have decided that the object of our interest is an insect that the trouble begins. It is sometimes very difficult to decide to what order it belongs. It is much to know this, and much more to know the family. Beyond this point it is unnecessary for the average entomologist to go. In the case of our more common insects, however, it is well to be able to recognize them by their generic and specific names, and with an acquaintance with the family to which they belong, they can readily be traced to their species.

It is sometimes necessary to enter into closer subdivisions, and, to this end, a higher and a lower section is provided, designated by the prefix *super* or *sub*, as *super-family* and *sub-family*, classing them above or below the regular family as their characteristics seem to indicate.

Dismissing the greater and more general divisions, we now come to the orders, and here we are met with confusion. It would seem as though science, or at least scientists, instead of making matters clear, as they should, take a delight in confusing. A student no sooner gets the system of nomenclature of a science firmly fixed in his memory, or the classification properly versed in his mind, than some new authority steps forward, and, in order to keep up with the times, the student has to unlearn all and learn over again.

There are several groups or orders of insects, ranging from seven to thirty-four, according to the authority. The commonly accepted number of orders has been seven. Westwood gives us thirteen, Comstock makes it nineteen, and Kellogg, the latest authority, gives us nineteen, but makes changes in Comstock's names and arrangement. The differences are in the minor groups or species.

There are six well-defined orders: Orthoptera, Hemiptera, Coleoptera, Diptera, Hymenoptera, and Lepidoptera. Then there is the seventh, the Neuroptera. Now it is an easy matter to assign an insect to any one of the six when it belongs there, but there are numbers of insects which do not clearly belong to any one of these, and the order Neuroptera has furnished a dumping-ground for most of them. When the entomologist found an insect which he could not clearly locate, he called it a Neuropteran, and let it go at that. This will answer as well,

for the purpose of our readers, probably, as any, as the more minute divisions, while undoubtedly correct, are more confusing and less suitable for the non-professional. So we will take the seven orders, as follows:

Orthoptera: The straight-winged; as grasshoppers, crickets, cockroaches, etc.

Hemiptera: The half-winged; as plant bugs, aphids, scale bugs, etc.

Coleoptera: The sheath-winged; as beetles of all kinds.

Diptera: The two-winged; as two-winged flies of all kinds.

Hymenoptera: The membrane-winged; as bees, wasps, ants, etc.

Lepidoptera: The scale-winged; as butterflies and moths.

Neuroptera: The nerve-winged. This order includes all the rest; as dragon-flies, lace-winged flies, etc.

The more minute division, according to Comstock, includes the following, which have principally been removed from the last-named order and erected into separate orders:

Thysanura: The bristle-tails, spring-tails, fish-moths, etc.

Ephemera: Mayflies.

Odonata: Dragon-flies.

Plecoptera: Stone-flies.

Isopoda: Termites or white ants.

Corrodentia: Book lice.

Malophaga: Bird lice.

Dermaptera: Earwigs.

Physopoda: Thrips.

Mecaptera: Scorpion-flies.

Trichoptera: Caddice-flies.

Syphonaptera: Fleas.

These minor orders are not of much interest to the average man, so it will not be out of place to consider them in their connection with the other orders which contain the great bulk of insects important to us, from either their beneficial or their destructive standpoint.

We have now some idea of the manner in which insects are divided into various classes, and it is necessary that we should learn the distinguishing features of them, in order that we may know to which of the various orders and families they belong. This we shall endeavor to make plain; but first it is necessary to know what an insect is, and something of the peculiarities which separate it from the other branches of the animal world. After considering this, we shall take up the principal orders and point out wherein they differ one from the other.

THE STRUCTURE OF INSECTS.

The external structure of insects is termed the *exo-skeleton*. In the *Vertebrata*, the bony framework of the body is internal and supports the muscular and nervous systems, which are attached to the outside of the osseous or bony system. With the insects, the reverse is the case. Here the skeleton is a hard, horny crust, composed largely of a substance called *chitine*, and it is situated on the outer surface, all the muscles and other organs of the body being attached to the inside, instead of the outside, of the skeleton. It is really a many-jointed tube, varying in size in different species, and composed of thirteen rings, most of them so articulated as to be movable at the will of the insect. Of these, the first composes the head, and is the most distinct. Three are fused together in the thorax, and, in most species, appear as one, there being no well-defined mark between the segments, which are immovably joined to each other. In the last section of the body the rings are loosely articulated and freely movable, being joined together with a yielding membrane, allowing the insect the widest freedom of movement. It must not be supposed, however, that these rings, or segments, are composed of one solid, unyielding piece, and that their only motion is at the joints. Each ring is composed of many plates, more or less movable, to accommodate the needs of the insect and to allow the movement of its various organs of locomotion, flight, etc. This outer integument, or case, varies very greatly in density in different insects; in some it is very thin, and easily crushed, while in others it is excessively hard. In some of the beetles, for instance, the wing covers are so hard that it is difficult to force a pin through them.

An insect is divided into three sections: the head, the thorax, and the abdomen. The upper portion, or back, is known as the dorsal surface, or *dorsum*; the under side is the ventral surface, or *venter*; while the sides are designated as the lateral surface, or *pleurites*. The upper and under surfaces of the thorax are sometimes designated respectively as the *notum* and *sternum*.

There are very many minor subdivisions into which the different sections of the body are separated, but it is not necessary in this treatise to name or enumerate them, nor for the young entomologist to learn them. If our readers desire to go deeper into the subject, the scientific text-books will give them an account of the more minute subdivisions and their various uses. It is enough for us to get a general idea of our subject, and we shall therefore have to proceed at once to investigate the three principal divisions, their attachments and various organs.

THE HEAD.

In insects, as in the higher animals, the head includes most of the sensory organs—the eyes, the antennæ, and the mouth parts, containing the organs of taste, and, in some species at least, the organs of smell also. The different portions of the head are: The epicranium, which is

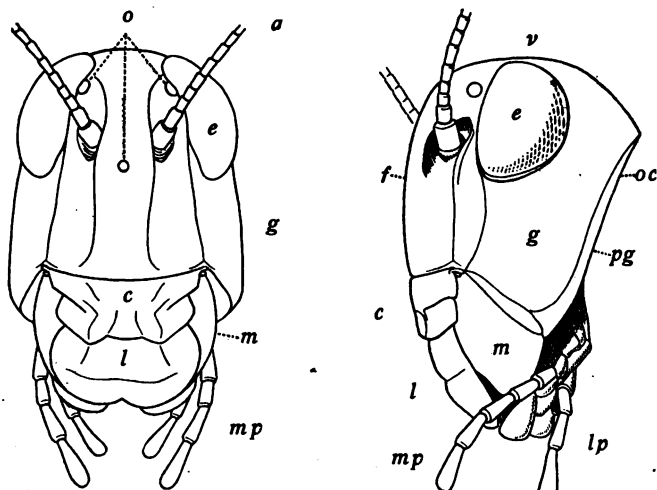


FIG. 6. Skull of a grasshopper (*Melanoplus differentialis*). a, antenna; c, clypeus; e, compound eye; f, front; g, gena; l, labrum; lp, labial palpus; mp, maxillary palpus; o, ocelli; oc, occiput; pg, post-genæ; v, vertex.

the upper or dorsal portion of the skull; the face, or front or frons above which is the vertex or forehead. The clypeus is in the lower portion of the face, and is the part to which the upper lip or labrum is attached. The cheeks are known as genæ, and in some species these

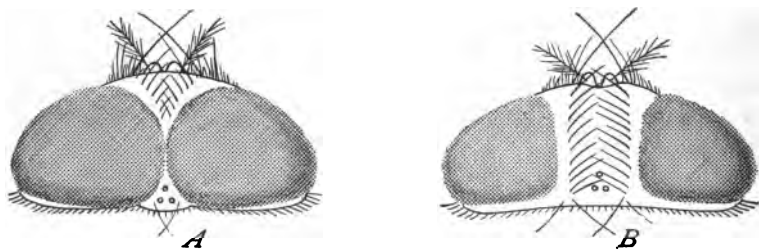


FIG. 7. Ocelli and compound eyes of a fly (*Phormia regina*). A, male; B, female.

are double, and we have post-genæ. On the under side of the head is the gula, to which the lower lip or labium is attached. The external top of the head, in contact with the prothorax, is the occiput. The principal organs of the head are the eyes, the mouth, and the antennæ.

Eyes.—In the perfect insect there is a pair of compound eyes. These are usually very prominent and highly faceted. In some insects,

as the dragon-fly, the house-fly, and others, they form the greater part of the head. The eye of an insect is immovable, fast in its socket. It is hemispherical or curvilinear in form, and covered with facets or flat surfaces. They are called compound eyes, and are of many colors—blue, black, emerald green, or deep golden, as in the lace-winged fly. Really,

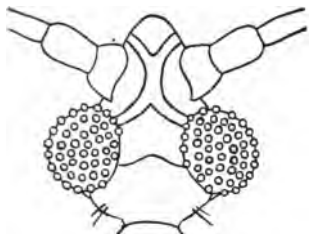


FIG. 8. Agglomerate eyes of a male coccid, *Leachia fuscipennis* (After Signoret.)

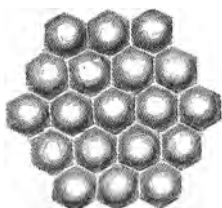


FIG. 9. Facets of a compound eye of *Metanopius*. Highly magnified.

each facet is a separate eye, hexagonal in shape, with a cornea, lens, pigment-coating, and nervous filament. The facets face in every direction and enable the insect to see on all sides with greater ease than if they were single lensed and movable. In some cases these facets are very numerous, the eye of a small beetle, the *Mordella*, having over 25,000, the common swallow-tailed butterfly, the *Papilio*, having 17,000, the dragon-fly 12,000, the house-fly 4,000, while the eyes of some ants are limited to 50. Besides these compound eyes, most insects have two

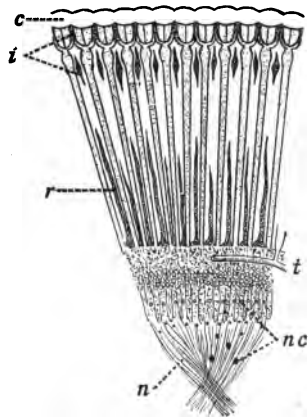


FIG. 10. Portion of compound eye of fly (*Calliphora vomitoria*), radial section. c, cornea; t, iris pigment; n, nerve fibers; nc, nerve cells; r, retinal pigment; t, trachea. (After Hickson.)

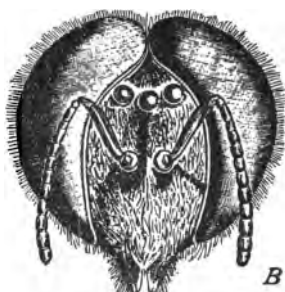
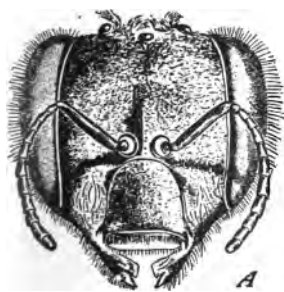


FIG. 11. Ocelli and compound eyes of the honey-bee (*Apis mellifera*). A, queen; B, drone. (After Cheshire.)

or three simple eyes, known as ocelli or stemmata. These are usually arranged in triangular form (thus \therefore), and are round and convex in shape. These extra eyes are not present in all insects, nor are their exact functions known.

They are possessed of great refractive power and are supposed to be of use in the examination of near-by objects.

Mouth.—The mouth is a very complicated piece of mechanism, and is furnished with various organs, enabling the insect to take its nourishment as its habits require. There are two general classes of

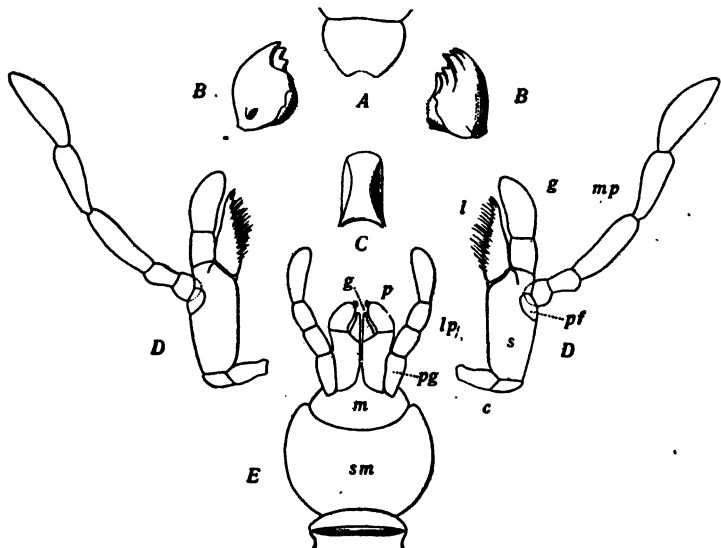


FIG. 12. Mouth parts of a cockroach (*Iachnoptera pennsylvanica*). A, labrum; B, mandible; C, hypopharynx; D, maxilla; E, labium; c, cardo; g, galea; g' (of labium), glossa; l, lacinia; lp, labial palpus; m, mentum; mp, maxillary palpus; p, paraglossa; pf, palpifer; pg, palpiger; s, stipes; sm, submentum. B, D, and E are in ventral aspect.

insects, distinguished from each other by their mouth parts, the one having biting or gnawing organs, and known as mandibulate insects.

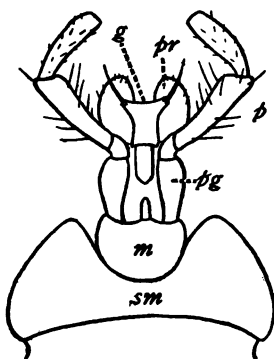


FIG. 13. Labium of *Harpalus caliginosus*, ventral aspect. g, united glossæ, termed the glossa; m, mentum; p, palpus; pg, palpiger; pr, paraglossa; sm, submentum. The median portion of the labium beyond the mentum is termed the ligula.

Beetles, grasshoppers, locusts, etc., belong to this class. In the other, the mouth parts are fitted for sucking only, and the insects acquire their nourishment by inserting their beaks into plants or animals and absorbing the juices by suction. These are known as haustellate insects, and in this class we find many of the greatest pests of the farmer and fruit-grower, among them the plant lice, or aphids, scale bugs, etc. In their perfect state, moths and butterflies derive their nourishment by suction, sipping the nectar from flowers with the long, thread-like tube which forms the mouth. Really, the haustellate mouth is a form of the mandibulate, modified to suit the habits of its possessor.

In the biting insects (Mandibulates) the mouth is composed of six different parts.

First, the mandibles, a pair of horny curved jaws, often serrated, or supplied with sharp, saw-like teeth. Secondly, a second pair of jaws located beneath the mandibles, and generally of four parts and arranged

for masticating the food torn off by the mandibles. These organs are known as the maxillæ. To these are usually attached one or two pairs of jointed organs, called palpi, or feelers. One pair of these is attached to the lower jaw or maxilla, and are termed the maxillary palpi, and the others are attached to the lower lip, and are designated the labial palpi. Their office seems to be somewhat like that of the tongue in

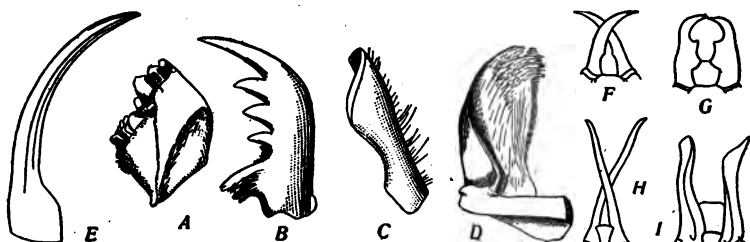


FIG. 14. Various forms of mandibles. A, *Melanoplus*; B, *Cicindela*; C, *Apis*; D, *Onthophagus*; E, *Chrysopa*; F-I, soldier termites. (After Hagen.)

the higher animals. Third, an upper lip, or labrum, attached to the lower portion of the head; and, fourth, the lower lip, or labium, with its attached palpi. The labium is usually composed of two or more parts, the mentum or chin, which is a broad, horny plate, varying in size in different species, and the ligula, or tongue, which lies on its inner surface. This is usually a membranous or fleshy organ, sometimes supported by a horny plate when it projects beyond the mentum.

Antennæ.—The antennæ are organs found in all insects, and are situated near the compound eyes and usually between them. These organs vary greatly in different insects and frequently even in the two sexes of one species. In some cases they are mere knobs, as in the ladybirds; in others they are much longer than the entire insect. They are sometimes feathered; sometimes branched, knobbed, or composed of a series of spherical joints joined together like a string of beads. In some cases they connect by a number of plates, and, throughout the whole class, they vary in structure almost as much as the species themselves differ one from the other. What the object of these organs is, has not been definitely determined. They are commonly called feelers, and certainly appear to possess a tactile sense. They may, in some cases, be organs of hearing, and sometimes seem to have auditory qualities. Experiments

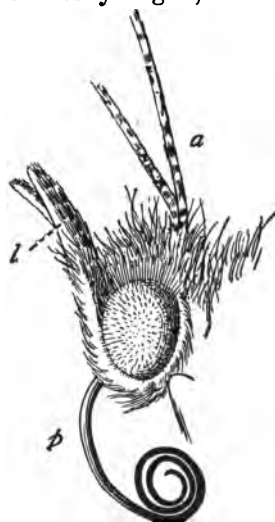


FIG. 15. Head of butterfly (*Vanessa*). p, labial palpus; a, antennæ; l, proboscis.

have shown that in some cases they are organs of smell. In fact, they may be any or all of these, or, as has been suggested, they may be the organs of a sense in insects of which we have no knowledge. Practically, there is but one sense, that of feeling. What we know as sight, hearing, taste, and smell are but different forms of feeling, and are caused by vibrations which convey to our special organs certain

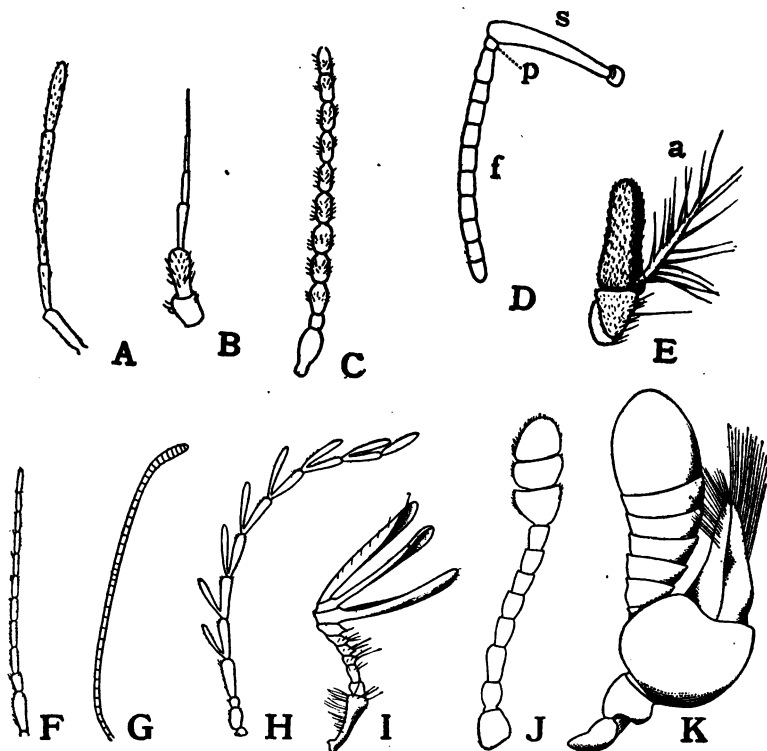


FIG. 16. Various forms of antennæ. A, filiform, *Euschistus*; B, setaceous, *Platemis*; C, moniliform, *Catogenus*; D, geniculate, *Bombus*; f, flagellum; p, pedicel; s, scape; E, irregular, *Phormia*; a, arista; F, setaceous, *Galerita*; G, clavate, *Anosia*; H, pectinate, male, *Ptilodactyla*; I, lamellate, *Lachnosterna*; J, capitate, *Megalodacne*; K, irregular, *Dineutus*.

sensations, which we designate by different names, but which depend for their reception upon the sensory nerves, and we therefore feel sound, color, flavor, and odors. The antennæ of insects are especially adapted to receive and convey the various forms of vibration, and it is not improbable that they may serve the purposes for which several organs are required in the higher forms of life. Let this be as it may, it is certain that the antennæ of insects are among the most important of their organs. They may be used also for the conveyance of information, as we know that ants and other insects on meeting will communicate to each other by means of their antennæ, and we know also that many insects, especially social insects, have the means of conveying information to each other.

It is necessary that some knowledge should be had of the different forms of antennæ, as these are all classified, and are sometimes used in the description of families. In the beetles, for instance, we have the Clavicornia, club horns; Serricornia, saw horns; Lamellicornia, thin plate horns, etc. So in order to describe the different forms of antennæ, they have been classified as follows (see Fig. 16):

Setaceous: Bristle-like.

Filiform: Thread-like.

Moniliform: Necklace-like.

Serrate: Saw-like.

Pectinate: Comb-like.

Clavate: Club-shaped.

Capitate: Ending in a head or knob.

Lamellate: Plates.

Geniculate: Jointed or kneed.

Besides these general terms others are used in describing the antennæ; as, plumose, or feathered; and "irregular," which includes many forms not included in the above list.

THE THORAX AND ITS APPENDAGES.

The foregoing will give the student a general idea of the head and its various organs, the eyes, the mouth, and the antennæ, and we will now proceed to consider the next im-

portant division of the body, the thorax. This is composed of three segments immediately back of the head. These segments are named pro-, meso- and metathorax. The first, or the one connecting with the head, being the prothorax, the middle section the mesothorax, and the last, the one connecting with the abdomen, being the metathorax. These segments appear to be solid rings, but really they are composed

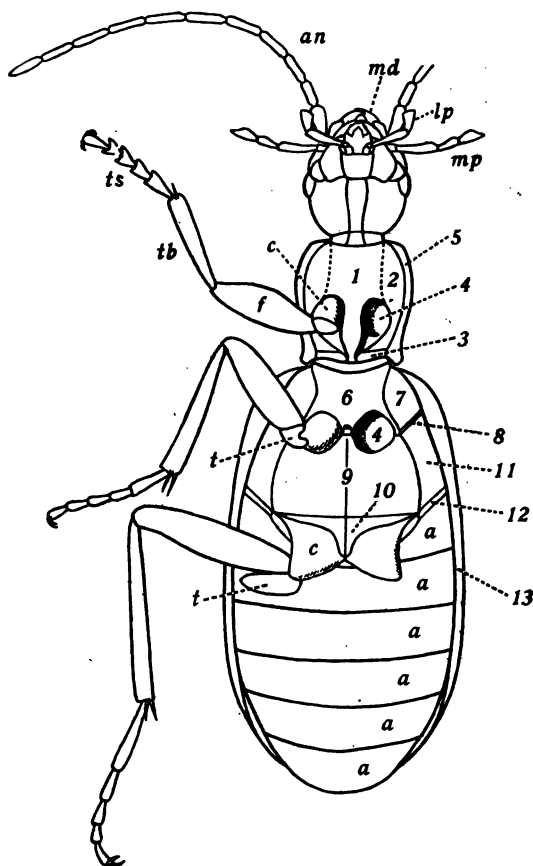


FIG. 17. Ventral aspect of a carabid beetle (*Galerita janus*). 1, prosternum; 2, proepisternum; 3, proepimeron; 4, coxal cavity; 5, inflexed side of pronotum; 6, mesosternum; 7, mesoepisternum; 8, mesoepimeron; 9, mesasternum; 10, antecoxal piece; 11, metaepisternum; 12, metaepimeron; 13, inflexed side of elytron; a, sternum of an abdominal segment; an, antenna; c, coxa; f, femur; lp, labial palpus; md, mandible; mp, maxillary palpus; t, trochanter; tb, tibia; ts, tarsus.

of several hexagonal plates, capable of motion and to which the various appendages are articulated. Each of these segments bears one pair of legs, but only the meso- and metathorax bear wings, and either or both pairs of wings may be wanting; as in the flies there is but one pair, and in many insects none.

Legs.—In most adult insects and many larvæ, each of the three thoracic segments bears one pair of legs, composed of several parts. That joint immediately attached to the body is known as the coxa, the next as the trochanter, femur, tibia, and tarsus, the latter corresponding to the foot in the higher



FIG. 18. Leg of a beetle (*Calosoma calidum*). c, coxa; cl, claws; f, femur; s, spur; t¹-t⁵, tarsal segments; tb, tibia; tr, trochanter.

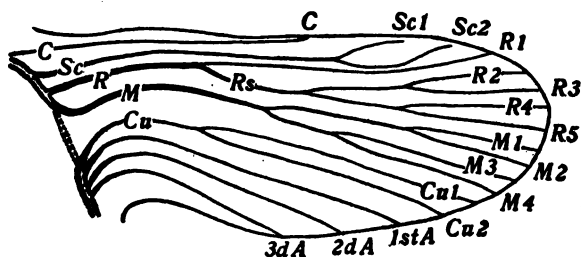
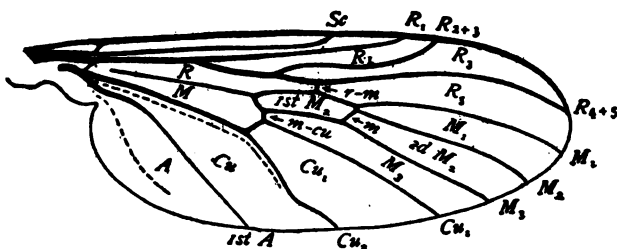


FIG. 19. Hypothetical type of venation. A, anal vein; C, costa; Cu, cubitus; M, media; R, radius; Sc, subcosta. (After Comstock and Needham.)

animals. The legs are modified in many ways to meet the requirements of the insect, and are adapted to running, leaping, swimming, burrowing, or grasping their



them. In earwigs and beetles the first pair of wings are represented by a hard, horny wing covering, known as the elytra. The upper wings are designated as superiors, anteriors or primaries, and the hinder wings as posteriors or secondaries. Commonly they are known as fore and hind wings, which is good enough for practical use.

The wings of an insect may be compared to a boy's kite, in which a light membrane is tightly stretched over a tough framework. In the insect we find a strong framework of horny tubes, termed veins or nerves, with a tough, membranous film on either side. The arrangement of these veins is called the venation or neuration, and is exceedingly variable, so much so that expert entomologists can tell to what order or family, and often to what species, an insect belongs by the arrangement of its

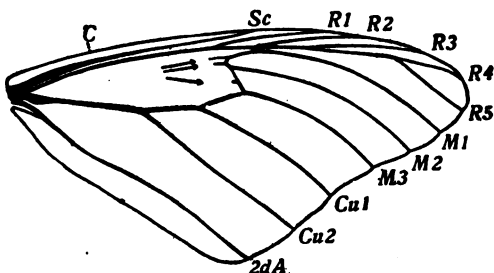


FIG. 21. Wings of a butterfly (*Anosia*). A, anal vein; C, costa; Cu, cubitus; M, media; R, radius. Sc, subcosta. (After Comstock and Needham.)

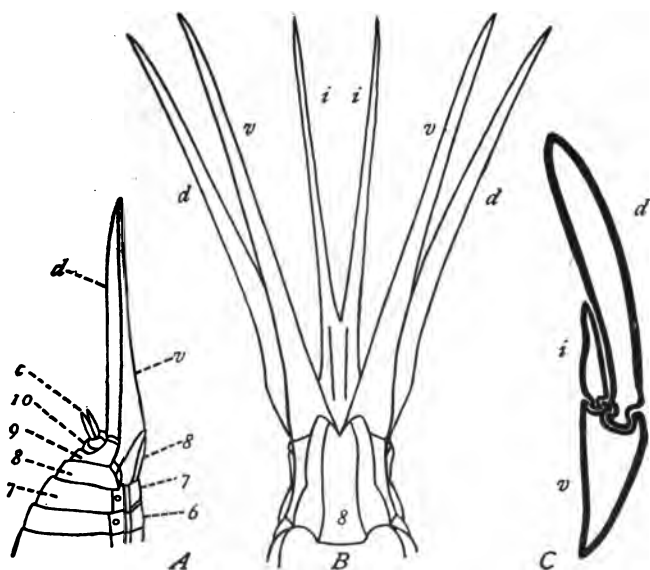


FIG. 22. Ovipositor of *Locusta*. A, lateral aspect; B, ventral aspect; C, transverse section; c, cerci; d, dorsal valve; i, inner valve; v, ventral valve. The numbers refer to abdominal segments. (After Kolbe and Dewitz.)

wing veins. The spaces between the veins are termed cells. With all this variation, however, in all wings there are certain well-marked veins, common to all, and these have all been named and numbered. The principal veins are known as the costa, subcosta, radius, cubitus, media, and anal. These are found in some form in all wings.

Insect wings vary not only in form, but also greatly in color and texture, and among them, especially in the butterflies, moths, and beetles, we find the most exquisite expression of color, form, and arrangement in nature.

THE ABDOMEN.

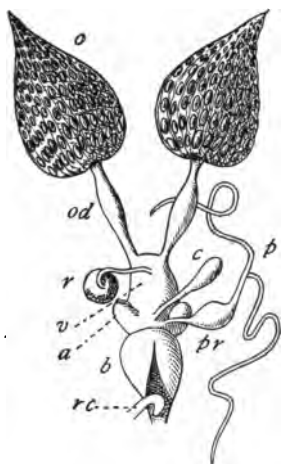


FIG. 23. Reproductive system of queen honey-bee. *a*, accessory sac of vagina; *b*, bulb of stinging apparatus; *c*, colleterial, or cement, gland; *o*, ovary; *od*, oviduct; *p*, poison glands; *pr*, poison reservoir; *r*, receptaculum seminis; *rc*, rectum; *v*, vagina. (After Leuckart.)

This is the third and last portion of the body, and is generally composed of nine segments. The number, however, varies greatly, and in the cuckoo-flies there are but three or four to be seen. The principal organs of the abdomen are those of respiration, digestion, and reproduction. The latter varies greatly in different species, especially in the female, in some cases being elongated into a long tube, the ovipositor; in some being supplemented with a sting; in others being supplied with sawing or piercing organs; all of which serve for the proper deposition of the egg in its future food supply, which instinct forces the mother insect to select.

As stated above, the abdomen is composed of nine segments, but these are not always distinct. It is usually considered as composed of two parts, the abdomen and post-abdomen, the latter being composed of the three terminal segments. In the abdomen proper, we never find articulated appendages, with perhaps the single exception of a small beetle, the *Spiractha eurymedusa*. On the post-

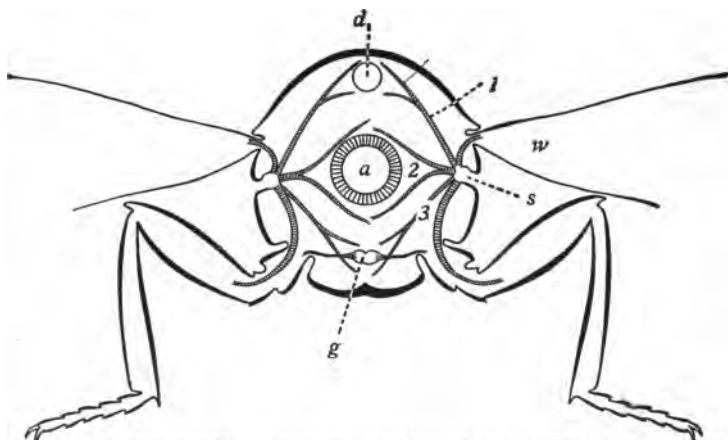


FIG. 24. Diagrammatic cross-section of the thorax of an insect. *a*, alimentary canal; *d*, dorsal vessel; *g*, ganglion; *s*, spiracle; *w*, wing; 1, dorsal tracheal branch; 2, visceral branch; 3, ventral branch.

abdominal segments, such appendages are frequently found; as the honey tubes of the aphids, the forceps of the earwigs, and the thick bristles of the cockroaches.

THE INTERNAL ORGANS.

Having now given a short account of the external organs of insects, we will glance at their internal organs, which comprise a digestive, circulatory, respiratory, and nervous system.

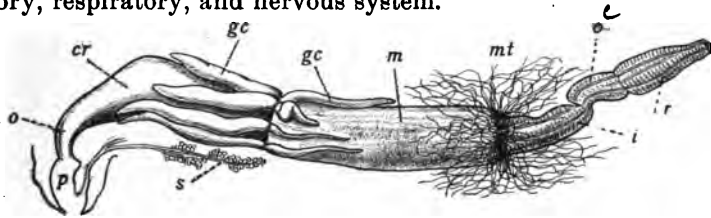


FIG. 25. Alimentary tract of a grasshopper (*Melanoplus differentialis*). c, colon; cr, crop; gc, gc, gastric caeca; i, ileum; m, mid intestine, or stomach; mt, Malpighian, or kidney, tubes; o, esophagus; p, pharynx; r, rectum; s, salivary gland of left side.

The digestive organs consist, as in the higher animals, of a continuous tube, somewhat longer than the body, varying in form with different insects, from a simple tube in the Thysanura, to a complicated system in the higher orders. It is usually supplied with a crop, gizzard, stomach, and necessary assimilative organs. The digestive tube is divided into three parts: the large intestine, the small intestine, and the rectum.

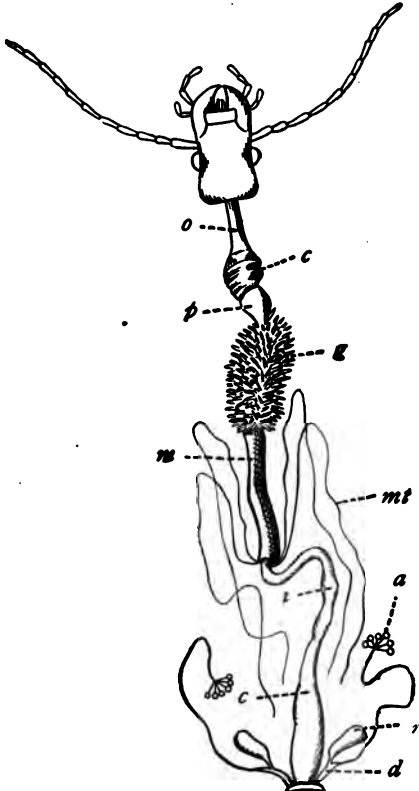


FIG. 26. Digestive system of a beetle (*Carabus*). a, anal gland; c (of fore gut), crop; c (of hind gut), colon, merging into rectum; d, evacuating duct of anal gland; g, gastric caeca; i, ileum; m, mid intestine; mt, Malpighian tubes; o, esophagus; p, proventriculus; r, reservoir. (After Kolbe.)

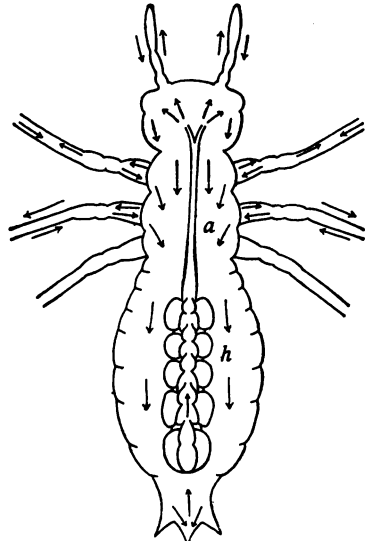


FIG. 27. Diagram to indicate the course of blood in the nymph of a dragon-fly (*Epiptera*). a, aorta; h, heart; the arrows show direction taken by currents of blood. (After Kolbe.)

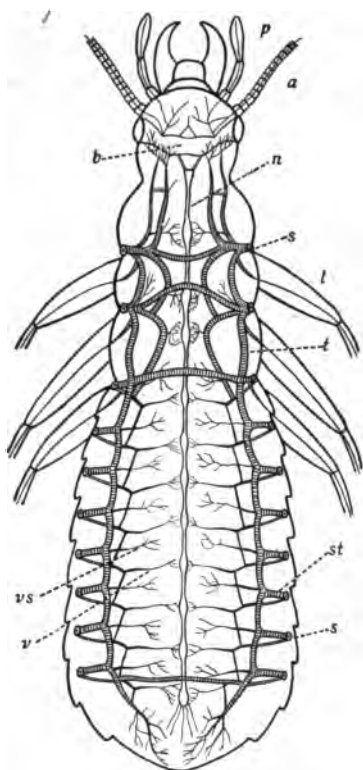


FIG. 28. Tracheal system of an insect. *a*, antenna; *b*, brain; *l*, leg; *n*, nerve cord; *p*, palpus; *s*, spiracle; *st*, spiracular, or stigmal branch; *t*, main tracheal trunk; *v*, ventral branch; *vs*, visceral branch. (After Kolbe.)

The circulation of insects is as yet imperfectly understood. The blood is cold, and, except for a slight yellowish tint, is colorless. There is no system of closed blood vessels, as in the higher animals, but the blood is forced through the body cavities by an organ which represents the heart. This organ is a delicate tube, located in the upper surface of the body, and is usually called the dorsal vessel. This represents the heart, and ordinarily consists of eight sections, or sacs, which open into each other and which, by contracting, drive the blood forward to the region of the head, where it escapes into the body cavity. No system of arteries or veins has been traced. In its course through the body, the blood becomes oxygenated by contact with the respiratory organs, which penetrate into all parts of the body. (See Fig. 27.)

The respiratory system consists of a vast number of tubes or tracheæ, which have their openings to the outer air along the sides of the insect. These air tubes are known as spiracles or stigmata. They are usually placed on each side of every segment, excepting the head, and communicate with a main tracheal

trunk which extends along the sides of the body. One of these trunks is situated on each side and from these the tracheæ branch off in all

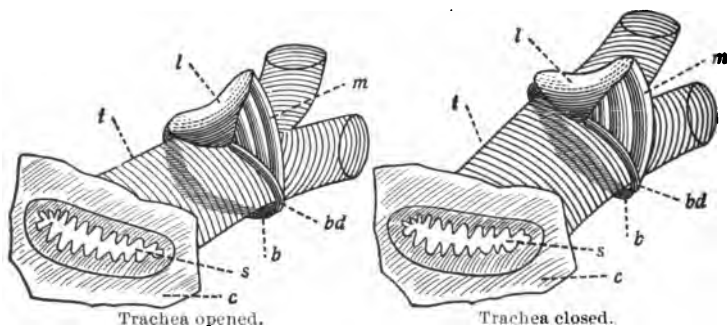


FIG. 29. Apparatus for closing the spiracular trachea in a beetle (*Lucanus*). *b*, bow; *bd*, band; *c*, external cuticula; *l*, lever; *m*, muscle; *s*, spiracle; *t*, trachea. (After Judeich and Nitsche.)

directions until the whole body is permeated with these delicate air tubes and thoroughly aerated.

The nervous system of insects consists of two thread-like cords running the length of the body, connecting which are nerve centers, or ganglia. From these centers, or ganglia, nerve threads branch and reach all parts of the body, governing the sense and motion of the insect. In the lower forms of life the brain is a mere nerve thread running through the body. As we advance from the lower to the higher, we discover small swellings or lumps along this thread. These are the ganglia, and each one forms a separate little brain, all connected with the main thread. Still further, we find, branching off from these ganglia, other threads, and we have a nervous system. In the higher animals, the bulb in the head is much the larger and dominates all the rest, and we know it as the brain, and the rest as the nervous system. In the higher animals there are two sets of nerves, one known as the

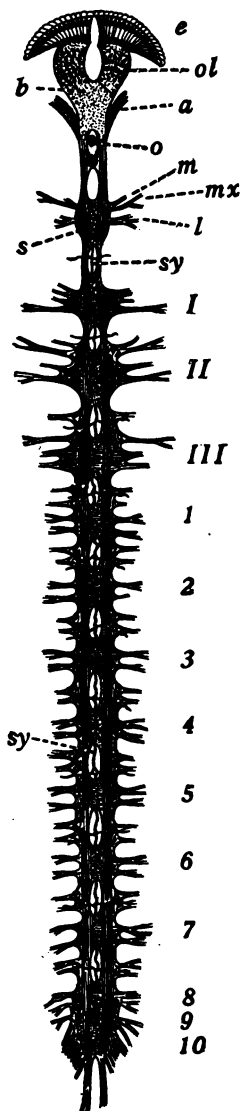


FIG. 30. Central nervous system of a thysanuran (*Machilis*). The thoracic and abdominal ganglia are numbered in succession. a, antennal nerve; b, brain; c, compound eye; l, labial nerve; m, mandibular nerve; mx, maxillary nerve; o, esophagus; ol, optic lobe; s, subesophageal ganglion; sy, sympathetic nerve. (After Oudemans.)

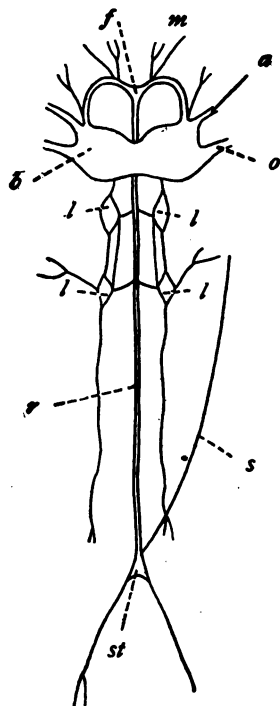


FIG. 31. Sympathetic nervous system of an insect, diagrammatically represented. a, antennal nerve; b, brain; f, frontal ganglion; l, l, paired lateral ganglia; m, nerves to upper mouth parts; o, optic nerve; r, recurrent nerve; s, nerve to salivary glands; st, stomachic ganglion. (After Kolbe.)

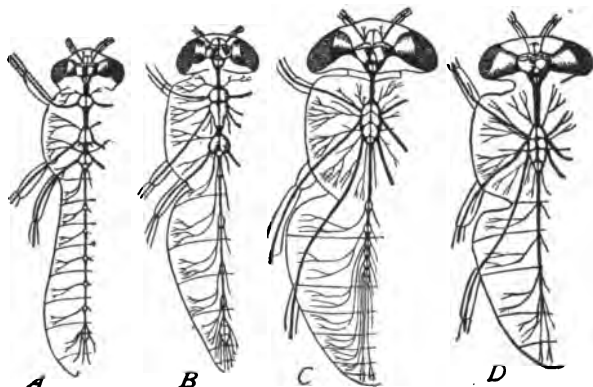


FIG. 32. Successive stages in the concentration of the central nervous system of Diptera. A, *Chironomus*; B, *Empis*; C, *Tabanus*; D, *Sarcophaga*. (After Brandt.)

sensory nerves, or those with which we feel and which convey impressions to the brain, and the motor nerves, or those which receive impressions from the brain. The one set enables us to feel, the other to act. With the lower insects the brain and nervous system are very simple, but in the higher orders it becomes more complicated, and is evidence of the possession of much intelligent force.

THE TRANSFORMATION OF INSECTS.

One of the most peculiar and wonderful of natural phenomena is the transformation or metamorphosis of insects—a process which, were it not so common and going on under our observation every day, would be unbelievable. If we did not know of it, and some traveler should tell us that in a distant country he had seen animals that in one stage of their existence were repulsive worms, and then became mummified,

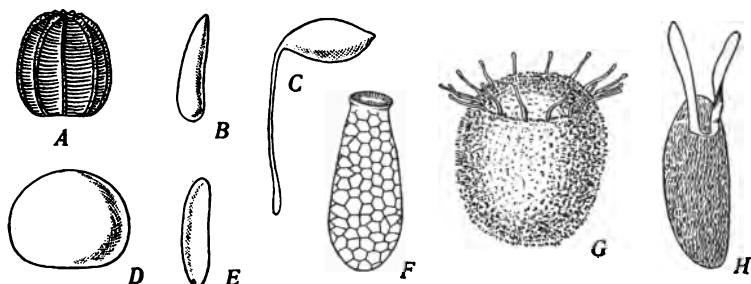


FIG. 33. Eggs of various insects. A, butterfly, *Polygonia interrogationis*; B, house-fly, *Musca domestica*; C, chalcid, *Bruchophagus funebris*; D, butterfly, *Papilio troilus*; E, midge, *Cecidomyia trifolii*; F, hemipteron, *Triphleps insidiosus*; G, hemipteron, *Podisus spinosus*; H, fly, *Drosophila ampelophila*. Greatly magnified.

losing all semblance to themselves, being practically dead for some time, and then broke forth from their mummy cases into the most beautiful and brilliant creatures imaginable, far exceeding any other animal in their beauty, we should regard him as drawing upon a very vivid imagination and relating things that were utterly impossible. Yet it is all true, and it is so common that it all passes under our eyes without a thought on our part of the wonder of it.

The insect passes through four stages: the egg, the larva, the pupa, and the imago. The egg is the germ, the beginning, the contained potentiality, which, under proper conditions, brings forth the new being. The second stage, the larva, is the growing period. In this the insect eats, increases in size, sheds its skin, or molts, several times, until it has stored up sufficient tissue for the final stage. But there is an intermediate stage, one of remarkable change, in which the insect ceases to be a mere eating, growing thing, and is transformed into its perfect shape. This is the pupal form. At last the final change takes place, and we have the new being in all its perfection.

It may be set down as an axiom that all the beauties of the animal and vegetable kingdoms are for the purpose of sexual attraction, the whole object of them being the continuation of the species. Plants are plain and uninteresting until they attain their growth and put forth their blossoms, and these blossoms, with their gorgeous hues and beautiful forms, are for the sole purpose of attracting the insects, the little go-betweens in the love-making of the plants, which carry the fructifying pollen from one to the other and make possible a future crop of plants, flowers, and seeds, and so it goes on forever.

It is so in the metamorphoses of insects. At the last it has ceased to be a gourmand. In many cases, its voracious appetite ceased with its larval life and it lives by sipping the nectar of the plants. It has now acquired its full sexual strength, its full sexual beauty, and its

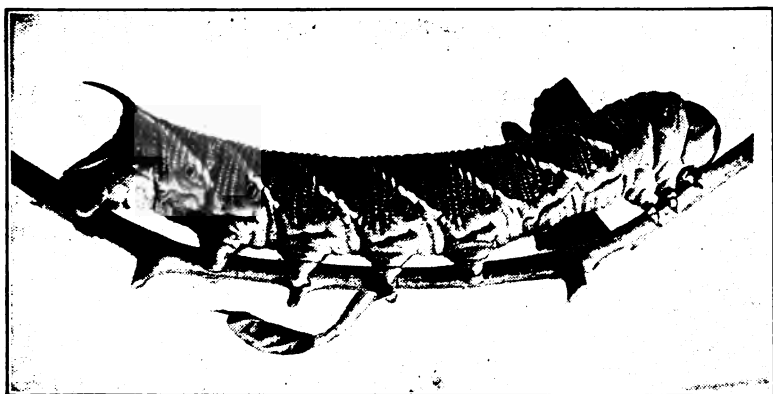


FIG. 34. Caterpillar of *Phlegthontius sexta*. Natural size.

great object in life now is to be attractive to the other sex. For this purpose the bright colors are developed in some, peculiar markings in others—strange shapes, rapid flight, strength, or other characteristics, having for their one object the continuance of the species. This accomplished, their life cycle has closed and they pass, like the rest of us, from this stage forever.

Metamorphoses are not similar in all the orders. In some of the orders we have what is known as "direct," or incomplete, metamorphosis; in this case there is no passive stage, and in many cases the change from the larval to the perfect form is hardly noticeable. In others, the larvæ, or nymphs, as they are called, molt several times, and, at the last, where they are winged at all, the wings develop and the insect becomes perfect, or enters upon the imago stage. Among insects of this class we have the bugs, or Hemiptera, the grasshoppers, crickets, cockroaches, and other members of the order Orthoptera. These insects passing through the direct metamorphosis are classed together under the name of Holometabola.

The other group, which have an "indirect" or complete metamorphosis, are grouped together as Heterametabola. In these, the insects pass through the regular stages: the egg, the growing larva, the pupa, and the perfect insect or imago.

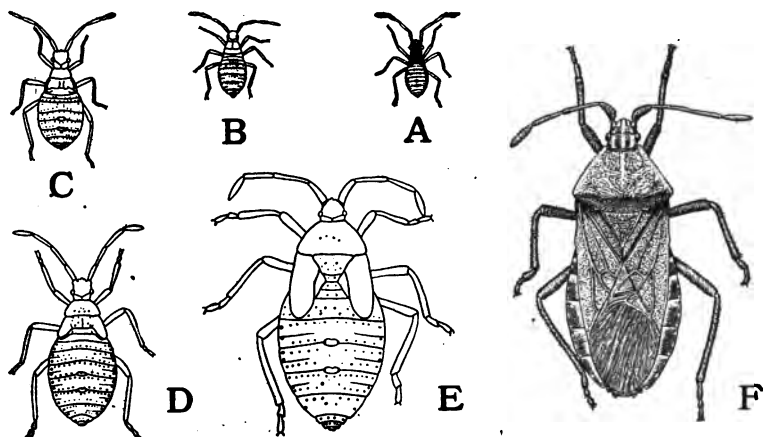


FIG. 35. Six successive instars of the squash-bug (*Anasa tristis*).

In the pupal stage of most insects having an indirect or complete metamorphosis, there is a strong approach to suspended animation, for while the pupa will sometimes squirm, when touched, it usually remains in perfect rest until the great change has been accomplished.

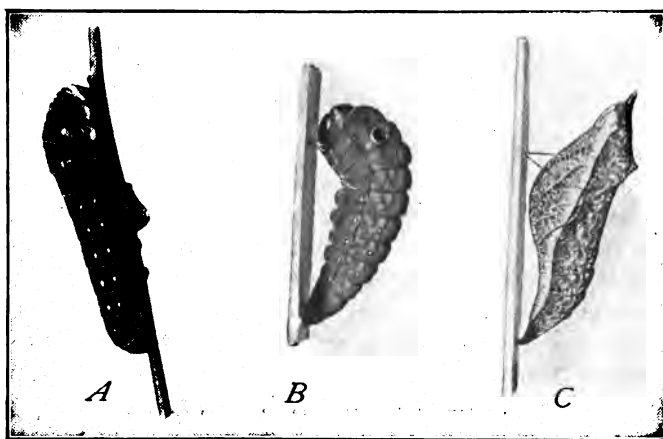


FIG. 36. *Papilio troilus*. A, larva; B, larva suspended for pupation; C, chrysalis. Natural size.

In those insects which have a direct metamorphosis, the insect in its transition stage is spoken of as a nymph.

The changing insect in other cases is known as a pupa, although in the case of butterflies it is often referred to as a chrysalis.

The change is one of the most wonderful operations in nature. It is as if the original larva had been entirely destroyed and an animal of an entirely new species had appeared. With its pupa integument, it has lost all the organs characteristic of the larval stage, and an entire new set have been provided. It now possesses six true legs, wings suited for rapid flight, compound eyes, antennæ, a more perfect nervous system, while, in the case of many insects, the sharp, gnawing jaws of the larva, which were adapted to cutting leaves or boring into wood, have been replaced with long, delicate tubes suited to absorbing the nectar of flowers. The very instincts of the insect are changed, and the life habits of the larva and the imago are as different as their outward appearance.

THE ORDERS OF INSECTS.

We have now given an outline of the structure and peculiarities of insects as a whole, and have reached a point where we can segregate them into groups or orders, which is necessary for closer study. As stated before, there are seven principal orders of insects—Orthoptera, Hemiptera, Neuroptera, Coleoptera, Diptera, Hymenoptera, and Lepidoptera. There are, as we said, several minor orders, but the above classification will answer our purpose and we will consider them in the order named.

Order **ORTHOPTERA.**

Orthoptera means straight-winged, and alludes to the fact that the hinder wings, when folded, lie perfectly straight down the back of the insect without any folds. The anterior wings are of little, if any, service in flight, serving principally as a covering for the large posterior wings, which, when spread, are semicircular in shape, and open and close like a fan. They are of large size, and the principal veins radiate, like the sticks of a fan, from the center. Not all members of this order are winged, however, many of them being apterous, or wingless.

The head is usually large and very prominent, and the antennæ either short, stout, and few-pointed, as in the locust, or very long and slender, as in the katydid. The head bears one pair of large compound eyes and usually two or three ocelli or simple eyes, and the mouth parts are suited for gnawing or biting.

The Orthoptera have a direct or incomplete metamorphosis. The young, when hatched, very much resemble the mature insect, and in the first or larval stage are wingless. They pass through several molts

when the wingpads appear, and they are now known as nymphs. At the last molt the wings are fully developed, and the insect is perfect.

They are voracious in all their stages, and while we find a beneficial member of the order in the mantis, we also find in it many of our most destructive insects, the grasshoppers, locusts, crickets, cockroaches, etc. Our readers are fully alive to the devastation wrought by one of the families of this order—the locusts—as California, and the whole Pacific Coast, frequently suffer severely from their depredations. With, perhaps, the exception of the *Cicada*, or seventeen-year locust, which, by the way, is not a locust, but a “bug,” as explained elsewhere, we find in this order the only “singing” insects, and the song of the cricket on the hearth and the katydid in the trees has given most people a kindly feeling for these destructive insects, not felt toward others.

The Orthoptera are classed in six families, which Comstock describes as follows:

The Running Orthoptera.—The body is oval when seen from above and is very flat; the three pairs of legs are similar in form; the insects run rapidly..... *Blattidæ*

The Grasping Orthoptera.—The prothorax is very long and slender; the first pair of legs are very different from the others, and are fitted for grasping..... *Mantidæ*

The Walking Orthoptera.—The body is very long and slender; the three pairs of legs are similar in form, and are also very long and slender; the insects walk slowly..... *Phasmidæ*

The Jumping Orthoptera.—The hind legs are very much stouter or very much longer, or both stouter and longer, than the middle pair, being fitted for jumping. This group includes three families:

The Short-Horned Grasshoppers, or Locusts.—The antennæ are shorter than the body. The ovipositor of the female is short and composed of four separate plates. The tarsi are three-jointed..... *Acrididæ*

The Long-Horned Grasshoppers.—The antennæ are very slender and longer than the body. (This is also true of the crickets.) The ovipositor is sword-shaped. The tarsi are four-jointed..... *Locustidæ*

The Crickets.—The antennæ, like those of the long-horned grasshoppers, are very slender and longer than the body, except in the mole-crickets. The ovipositor is spear-shaped when exerted. The tarsi are three-jointed..... *Gryllidæ*

These families are sometimes grouped in two large sections: the Saltatoria, or the leapers, in which the hind legs are much lengthened and formed for jumping, as the crickets, grasshoppers, and locusts, and the Cursoria, in which the legs are formed for running, as the cockroaches, etc. The latter group includes the first mentioned three families, and the first group the others.

Section CURSORIA.

Family Blattidæ. At the head of the section Cursoria is placed the Blattidæ, or roaches. While few of them are known to California, there are a thousand or more species in the world. Many of these live in the fields and find shelter under sticks and stones. Some are wingless, and all are nocturnal and very fond of heat and moisture. It is on

this account that they swarm in kitchens, around sinks, in pantries, the holds of ships and steamers, and similar locations.

The female lays her eggs in a purse-like pouch, in a double row, which she carries with her for some time before she deposits it. This mass resembles a small, brown bean in shape. In some cases it is asserted that the female remains with and cares for her young. They breed in enormous quantities, and once introduced into a house will soon overrun it, but on account of their nocturnal habits and timorous disposition, they may be present in quantities, yet remain unsuspected. Going suddenly into the kitchen with a light will sometimes show them by hundreds scampering off in all directions for a place of retreat.

Like most of our pests, the worst of the cockroaches is an introduced species. They are omnivorous in diet and do much damage to books and clothing, besides overrunning and devouring food in the pantry and cupboards.

Insect powder freely dusted over books and similar articles will drive them away, while powdered borax mixed with sugar, of which they are very fond, will kill them in large numbers.

Family Mantidæ (The Mantis). This family includes about twenty species in our country, and is the one beneficial family of the order. From its peculiar habit of holding its head erect, its fore legs raised, and remaining motionless in this position for some time, the most conspicuous member of the family has been named "The Praying Mantis." If a pun were permissible, it might be called "The Preying Mantis," for its patience, devout attitude, and generally saintly appearance are designed to throw other insects off their guard, which, when they come within reach of the waiting, watchful mantis, are quickly grasped between the fore legs, their juices sucked from their bodies, which are then thrown aside, while the mantis again assumes its devotional attitude and awaits a fresh victim.

All the species of Mantidæ are carnivorous, but in securing their prey they depend altogether upon their resemblance to twigs, leaves, etc., and wait for their victims to come within their reach, when they are quickly seized and devoured. The eggs are laid in masses, inclosed in a soft silk-like substance, through which the young gnaw their way as soon as hatched. These insects are cannibals, for if there is no other food within easy reach the young will devour each other.

Family Phasmidæ (Walking-sticks). This is a peculiar family, and comprises within it some of the largest and most monstrous appearing creatures of the insect world. They are strangely formed and depend for their protection and their food upon their mimicry. Some of them strongly resemble green twigs, others dry twigs, some the leaves of trees, and so strong is the likeness that it is almost impossible to detect them

upon the tree where they are at rest. These insects are most numerous in the tropics, where they sometimes attain a length of eight or ten inches. All are vegetable feeders, and would become injurious were they introduced and acclimated, but, being tropical, there is little danger from this source.

Some members of the family are found in the Eastern states, through the Mississippi Valley and in the South, but none have ever been reported from California.

Section **SALTATORIA.**

Family **Acerididæ** (The Locusts). This is a family in which we are especially interested, as it includes the most destructive foes of the farmers of the West. The members of this family are distinguished from others of the order in having the antennæ—composed of from six to twenty-four joints—shorter than the body. It is from this fact that they are sometimes called the short-horned grasshoppers.

The females lay their eggs, usually underground, but sometimes in other locations, in an oval, bean-like mass. The number of eggs in each mass varies from twenty or thirty to double that number. The holes for the reception of the eggs are made by means of two pairs of horny valves at the tip of the abdomen of the female. These open and shut rapidly and are well adapted to execute this function. The female, by pressing the tip of her abdomen forcibly against the soil, rapidly opens and shuts these hard-pointed valves and soon pushes them into the ground, thus drilling a hole. In a short time the entire and greatly extended abdomen is inserted in the little curved and more or less oblique cavity. The legs are hoisted above the back during the operation of drilling the hole, which requires more or less time, depending entirely upon the character of the soil. As soon as the hole is finished, it is filled with frothy and mucous material.

Professor Riley describes the method of egg-laying as follows: "By repeatedly extracting and studying specimens in every stage of oviposition, we have been able to ascertain the exact method by which the egg mass is formed. If we could manage to watch a female from the time the bottom of her hole is moistened by the sebific fluid, we should see the valves all brought together, when an egg would pass down the oviduct along the ventral side, and, guided by a little finger-like style, pass in between the horny valves, and issue at their tips amid the mucous fluid already spoken of. Then follows a period of convulsions, during which more mucous material is elaborated, until the whole end of the body is bathed in it, when another egg passes down and is placed in position. These alternate processes continue until the full complement of eggs are in place, the number ranging from twenty to thirty-five, but averaging about twenty-eight. The mucous matter

binds all the eggs in a mass, and when the last is laid, the mother devotes some time to filling up the somewhat narrower neck of the burrow with a compact and cellular mass of the same material, which, although light and easily penetrated, is more or less impervious to water, and forms a very excellent protection. When fresh, the mass is soft and moist, but it soon acquires a firm consistency."

The Rocky Mountain locust (*Melanoplus spretus*) is the most dreaded of any of our American species. This species finds an ideal breeding place in the high plateaus of the Rocky Mountains, where tens of thousands of square miles have been untouched by the plow for all the ages. Here they breed undisturbed, and by countless millions, and those who have never seen a flight of these insects can form no idea of their numbers—or

perhaps, of their quantity, for numbers is an inadequate term. In their flight, they will sometimes swoop down upon a fertile section and in a short time devastate hundreds of square miles. Kansas has suffered severely from their depredations, until Kansas and locusts have become connected in the mind. Yet these insects are not indigenous to

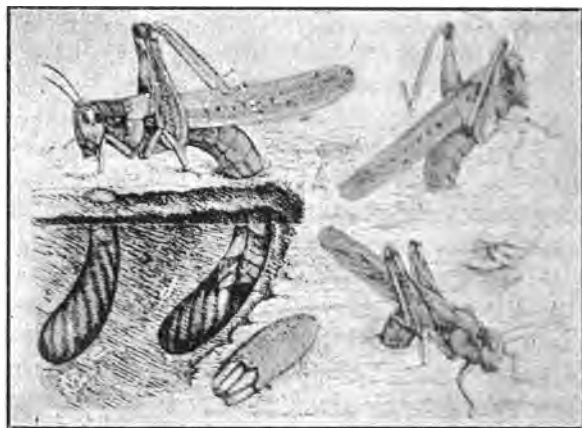


FIG. 37. Rocky Mountain locust (*Melanoplus spretus*) ovipositing. Females with abdomen inserted in the soil; egg-pod broken open and lying on the surface; a few scattered eggs; section of soil removed to show eggs being put in place, and egg-pod sealed over.

Kansas, nor can they thrive there. Their natural habitat is the high plateaus of the Rocky Mountains at an elevation of from 2,000 to 10,000 feet. Here, when their food supply becomes short, a swarm will sometimes rise in the air, and on their expanded wings may be carried hundreds of miles on an air current until they alight in a place far distant from their breeding grounds. Thus they reached Kansas and did damage for several years. Each year their numbers became fewer until they disappeared, Kansas and its climate not being suited to them.

Swarms of Rocky Mountain locusts reach Utah, Idaho, Nevada, and frequently eastern California; occasional small swarms pass over the Sierra Nevada range, but on this side of the range they have never been very numerous or in sufficient quantities to be serious.

There is, however, a close relation to this pest—*Melanoplus devastator*—with which California is too well acquainted. This is the locust which appears in swarms each season in some parts of the State, the foothill regions of the Sacramento and the San Joaquin valleys being especially afflicted with their visitations. Fortunately their breeding grounds are not so extensive, their swarms much smaller, and their destructive powers vastly less than *M. spretus*. But they are bad enough. From historic records, it is evident that this pest was much worse in California in early days than at the present time, swarms of them having been recorded even near San Francisco. This is natural, as the insects breed in the wild, uncultivated land, and, as the country becomes more densely settled and more intensely cultivated, their breeding area is more and more circumscribed, their swarms reduced, and their destructive area lessened. Their favorite breeding grounds are now found on the warm slopes of the foothills, those having a southwestern exposure being preferred. Here, where the soil is too thin for agricultural purposes, and is left undisturbed, large swarms of *M. devastator* breed and do great damage on the cultivated lands in the vicinity. Fortunately, there are efficient parasites for these pests, and they do not often appear in destructive numbers for two years in succession in the same place.

Grasshoppers in such localities usually make their appearance during the latter part of May, and in the following months of June and July cause their greatest destruction. After that, effects of disease, attacks of natural enemies, and their extension over a wider area so reduce their numbers in a given locality that their depredations are comparatively so small as to pass unnoticed.

Grasshoppers generally first appear in greatest numbers along the edges of the foothills, which are their breeding ground, in isolated swarms, often many miles apart. When first hatched, their powers of destruction are not great; but with each molt their voraciousness increases, and unless steps are promptly taken to combat them, or unless attacked by their natural enemies in numbers, cultivated crops in their path may be seriously injured or destroyed by them.

The grasshopper has many enemies. A tachina fly, about the size of the common house-fly, and which it much resembles, is one of the most abundant and most destructive to the hoppers. Birds also aid greatly in their destruction. The common meadowlark is among the most active destroyers of this insect. When grasshoppers are plentiful the meadowlark does not eat the entire insect, but only the abdomen or a portion of one, and this habit enables it to destroy a great number every day. Blackbirds of all varieties are also great aids in destroying them, but, unfortunately, the birds are breeding and taking care of their young when the grasshoppers first appear, and as their nesting-

places are close to water in the tules and the breeding grounds of the grasshoppers are near the foothills, perhaps miles away, their services are not so valuable in proportion to their numbers as those of the meadowlark, whose home may be in the midst of the young grasshoppers or adjacent thereto. Later in the season, the blackbirds become fearfully destructive of grasshoppers. Woodpeckers also for a time cease their arboreal habits to prey upon the grasshoppers on the ground. While the sparrowhawks, owls, sparrows, groundlarks, and, in fact, all kinds of land birds, except the dove, give their welcome aid in destroying the pests. It is said that skunks and gophers eat them, as do also toads, frogs, and snakes.

Grasshoppers, like all insects that gather in large swarms, are subject to contagious diseases, which spread rapidly and carry them off in large numbers, often almost exterminating them. A fungus disease is one of the most fatal to grasshoppers in some countries.

But when grasshoppers become numerous and destructive, it is not wise for farmers or horticulturists to await the action of natural causes, for proximity to cultivated areas does not give the necessary time for their action before great damage has been done. The farmer must, therefore, be prepared to defend his crop. The best method to combat the pest is to plow the land known to contain eggs, before the grasshoppers are hatched. When the young hoppers have appeared, they may be plowed under and destroyed. Plowing should commence at the outer boundary of the grasshopper section, and a number of plows should be used at the same time, the plows following each other as closely as possible. The grasshoppers are in this manner forced to the center, where a black mass of struggling insects are crowded together. But few of them will escape, for as one plow makes a furrow, which is rapidly filled with grasshoppers, the following plow covers them under and they are buried alive, few of them escaping.

The genus *Melanoplus*, to which both of the above described locusts belong, is a very extensive one, including one hundred and twenty species in the United States, and is the largest of all the Acridid genera.

The next most destructive member of the subfamily Acridinæ is the *Edaleonotus enigma*, which species is sometimes very numerous and destructive.

Family Locustidæ. Dismissing the family Acrididæ, which includes the numerous and destructive locust genera, we come to the next family, the Locustidæ, to which, by the way, the locusts do not belong. This includes the katydids, meadow grasshoppers, wingless crickets, etc. Their common and peculiar characteristics are their very long antennæ, which, in many species, greatly exceed the length of the body, and the prominent wings in many of those which have these

organs. In those species which have well-developed wings, the males are provided with an elaborate musical apparatus, the use of which is to call the females. The chirping made by these insects is familiar to most people, to all who have spent a summer in the country, and the short rasping sound made by one species (*Cyrtophyllus concavus*) has given it the popular name of katydid, which its song is supposed to resemble. In the different species, each has its own distinct note, and entomologists who have made a special study of them can distinguish each by its peculiar sound.

Comstock arranges the Locustidæ in four general groups for facility in studying, to which he gives the everyday names of:

1. The Meadow Grasshoppers, including the smaller and common members of the family, which abound in meadows and moist places.

2. The Katyids, or tree crickets, generally bright green in color, strongly resembling the foliage among which they live, and which render night musical with their songs. One of the most common of these in California is the angular-winged katydid (*Microcentrum retinervis*). The eggs of the insect are laid in a double row along the edge of a leaf, a twig, or other object, overlapping each other like a row of shingles, and are often mistaken for scale insects.

3. The Cricket-like Grasshoppers, which are found under stones and rubbish, especially in woods, and which are wingless.

4. The Shield-back Grasshopper, also wingless, dull colored, and resembling crickets. This group is represented in California by the *Stenopelmatus irregularis*, a large, clumsy creature, with a big head and long antennæ, which lives under stones and strongly resembles the mole or Indian cricket.

Family Gryllidæ (The Crickets). The members of this family of jumping Orthoptera resemble the Locustidæ, in that they have long, slender, tapering antennæ, but differ from them in having the wings laid flat on the back, the forewings bent down on the sides. The ovipositor in the female is long and pointed, while in the Locustidæ it is flat and sword-like. The males of this family are the greatest of all insect musicians, and the sharp chirp, chirp, chirp of the cricket is well known. The commonest and best known of these insects is the field cricket, which appears in such quantities in our country towns on warm summer nights, where they are attracted to the electric light and perish by millions without apparently diminishing the next season's supply. Every warm night in every summer brings them out in countless swarms. It is this insect that we generally understand as being meant when the cricket is alluded to, yet it is but one of a very numerous family, comprising eight subfamilies, each containing several genera and species. These, however, are classed into three distinct groups, a

classification ample for any but the most minute, scientific study. These groups are:

1. Mole Crickets, heavy bodied, large-sized burrowing insects, frequently brought to the surface in digging or plowing. This is among the most peculiar of these insects. It is well named the "mole cricket," as in its general form and habits it resembles that animal. The front legs are short, very stout, and furnished with strong tibiae, well suited for digging and much like the fore paws of the mole. These insects live wholly underground, and feed upon the tender roots of plants, becoming a very serious nuisance where they are numerous.

2. True Crickets, which include the common house and field crickets, which visit us in such hordes in the summer nights. The eggs of these insects are generally laid in the fall, in light, sandy soil, and remain until

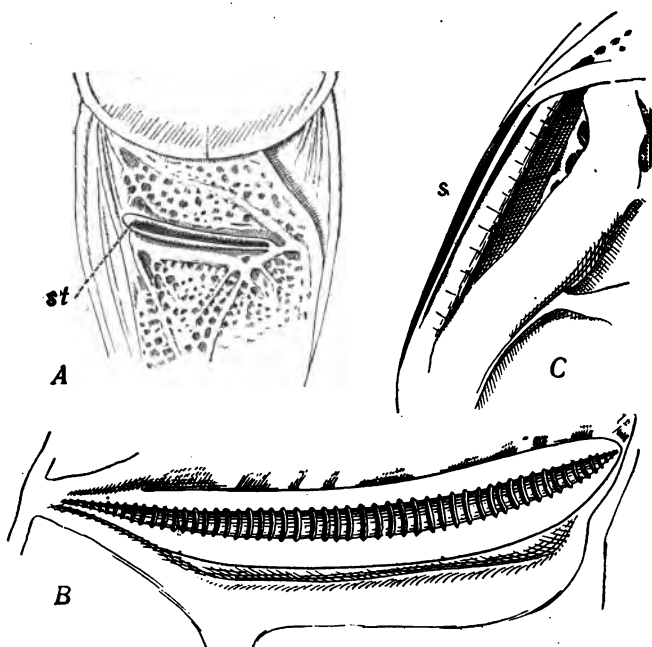


FIG. 38. Stridulating organs of *Microcentrum laurifolium*. A, dorsal aspect of file (st) when the tegmina are closed; B, ventral aspect of left tegmen to show file; C, dorsal aspect of right tegmen to show scraper (s).

spring, when they hatch and the young begin to eat, grow, and molt, until they attain their growth and their wings later in the summer, when they become very much in evidence. They are serious pests, being omnivorous feeders, and will devour anything in their way. If they secure entrance to the house, which they often do, cotton and woollen fabrics alike will be damaged by them. They are in no way choise in the matter of diet and do not turn away from their own kind, but will devour each other with avidity and a keen relish.

3. Tree Crickets, which are found on trees and shrubs, as a rule, although they are sometimes found on grass and herbs. They are delicate and rather small insects, as compared with other members of the family. In laying her eggs the female cuts a groove in the tender canes of raspberry and blackberry vines, or of fruit trees, and in these

her eggs are deposited in a long row. Much damage is often done from this cause, when the insect is numerous, as the twigs are likely to die above the point of damage.

The Earwigs.—Until recently the earwigs were classed with the Orthoptera, but a new order, *Euplexoptera*, has been erected for them.



FIG. 39. Full-grown larva of earwig (*Forficula auricularia*). Enlarged.

These insects are readily recognized by the forceps-like appendages at the end of the body. These organs are used in folding the wings of the insect, which are snugly tucked away under the wing covers when at rest. They are vegetable-feeders, and where numerous do much damage. They are nocturnal in their habits and are not frequently met with in the daytime.

In California the order is represented by *Amsolabis*, a black, wingless species, about three fourths of an inch long, with short, heavy forceps.

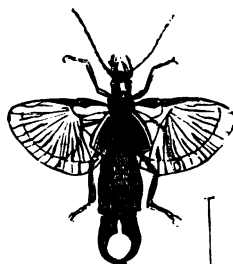


FIG. 40. Adult earwig (*Forficula auricularia*). Enlarged.

Order HEMIPTERA.

We now come to the order of most importance to the fruit-grower and the farmer, for in this we find the greater number of enemies of plant life; in fact, while there are some beneficial species in it, we may say that it is the pest order of the insect world. In this we find the entire group of scale bugs, the aphids or plant-lice, the phylloxera of the grape, and woolly-aphis of the apple; it gives us those most detested of all insects, bedbugs and lice. It is a bad order, but as there is no such thing as unmixed evil or absolute good, so even this order, composed as it is wholly of suckers, supplies us with some members that work for our good. There are those which prey upon their kind; the assassin-bugs as they are called, from the fact that they are predaceous upon other insects and live by sucking the blood of their fellows.

The name *Hemiptera* means half-winged, and these insects are so named from the fact that most of the members of this order have wing covers that are partly thick and leathery, and partly thin and membranous. While this name was given to the order at an early date, and was tolerably applicable to it, still there were found to be a great many insects which properly belonged here to which it was not applicable, as their wings were not half-and-half, so the order has been divided into two suborders, called *Heteroptera*, having diverse wings, and *Homoptera*, having similar wings, so an insect in this order is either *Hemiptera homoptera*, or *Hemiptera heteroptera*. There is still another group belonging to this order, the members of which are wingless, which prey

upon other animals, and protect themselves by hiding on the body of their host, or crawling away in cracks and crevices, to issue in the night when all is still and suck the blood of their victims. This group is known as *Parasita*, and will need little further allusion, as it only indirectly affects the orchardist and farmer.

The Hemiptera is one of the most numerous of all the orders. It includes over five thousand known species in North America, and to it belongs the one suborder which the entomologist recognizes as "bugs." To the lay mind all insects are bugs, but to the scientific mind the term brings up a member of the order *Hemiptera heteroptera*; these are the true bugs.

Like the preceding order, the metamorphosis is direct or incomplete. The young insect, as soon as hatched, strongly resembles the adult in shape, and, in many cases, in coloring. It is wingless in its earlier stages, and in some species always so, and passes through several molts in attaining its adult form. The winged species acquire their perfect wings after the last molt.

The members of this order are very diverse in form, size, and markings, and there is no order in which there is such disparity in the appearance of the different families. We have within it the *Cicada* and the mealy-bug, the giant water-bug, which is attracted to the electric light in such great numbers as to have acquired the name of "electric-light bug," and the common scale-bug. In it we find giants of the insect world, and species so minute as to require a strong glass to make them visible. But all through, there is one characteristic which is possessed in common by all, big and little alike—they are all suckers, and live by imbibing the juices or blood of plants and animals. They form the greater part of the Haustellates, or sucking insects, the other half of the insect world being known as the Mandibulates, or biters—a very respectable group compared with the one we are now treating on. The mouth parts are formed for piercing and sucking, and vary in length in different species. The sucking beak can readily be seen by examining the insect, where it will be detected on the under side, folded close to the body. In many species there is a groove into which the beak fits snugly when not in use, and in these it is sometimes difficult to detect it. This beak is really a compound instrument, and is composed of four bristles inclosed in a jointed sheath. Two of these bristles are supposed to represent the mandibles and two the maxillæ of the mandibulate insects, while the sheath takes the place of the labium.

As stated, this order is divided into three suborders: 1. *Parasita*; 2. *Homoptera*; 3. *Heteroptera*.

Of the first of these, little more need be said. Nearly every animal and most birds have a particular species of lice which prey upon them, and people engaged in breeding animals and fowls are sometimes confronted with a serious problem in getting rid of them. This is said

be a degraded family, since they have through their degraded habits lost their wings, and to a great extent powers of locomotion, being wholly dependent upon the bodies of their hosts, to which they are attached all their lives. They have, however, become highly specialized for this style of life, and are well adapted for it.

While on this subject we may state that the bird-lice are not true lice, nor do they belong to the order now under consideration. With the true lice, the mouth parts are made for suction—haustellate—and they properly belong to the Hemiptera, the bird-lice and the book-lice have biting mouth parts, and for these separate orders have been erected, the biting bird-lice being classified as *Mallophaga*, and the book lice as *Corrodentia*.

Suborder **HETEROPTERA**. (The True Bugs.)

The word Heteroptera means having diverse or different wings, and included in this suborder are the true bugs of the entomologist, for while, as before stated, to the average person all insects are bugs, to the entomologist the term means only members of this suborder.

The common squash-bug may be taken as the type of this group. When winged, their wings differ from the suborder Homoptera in the composition and position of the wing covers and in the direction of the head. The insects in this suborder have the head horizontal, on a plane with the body, the beak arising from the front. The wing covers lie flat on the back, and are composed of three separate pieces: corium, clavus, and membrane. These parts are modified in different species in a great variety of ways.

The young of this suborder are known as nymphæ, and after the third molt show the rudiments of wings. The nymphæ are sometimes quite different in coloring to the mature insect. Some difficulty has been experienced in arranging a perfect synopsis of this suborder, which has been arranged in twenty-six families. They have been divided into two groups, the long-horned bugs and the short-horned bugs. About one third of them live in the water, a large section near the water, and the rest on land. They may therefore be classed as Aquatic, Amphibious, and Terrestrial bugs. The following synopsis of families is arranged by Comstock:

THE SHORT-HORNED BUGS. Bugs with short antennæ, which are nearly or quite concealed beneath the head.

BUGS THAT LIVE WITHIN WATER.

- The Water-boatmen. Family Corisidæ.
- The Back-swimmers. Family Notonectidæ.
- The Water-Scorpions. Family Nepidæ.
- The Giant Water-bugs. Family Belostomidæ.
- The Creeping Water-bugs. Family Naucoridæ.

BUGS THAT LIVE NEAR WATER.

- The Toad-shaped Bugs. Family Galgolidæ.

THE LONG-HORNED BUGS. Bugs with antennæ at least as long as the head, and prominent except in the Phymatidæ, where they are concealed under the sides of the prothorax.

THE SEMI-AQUATIC BUGS.

- The Shore-bugs. Family Saligidæ.
- The Broad-shouldered Water-striders. Family Veliidæ.
- The Water-striders. Family Hydrobatidæ.
- The Marsh-treaders. Family Limnobatidæ.

THE LAND-BUGS.

The Land-bugs with four-jointed antennæ.

- The Thread-legged Bugs. Family Emesidæ.
- The Assassin-bugs. Family Reduviidæ.
- The Damsel-bugs. Family Nabidæ.
- The Ambush-bugs. Family Phymatidæ.
- The Flat-bugs. Family Aradidæ.
- The Lace-bugs. Family Tingitidæ.
- The Bedbug and the Flower-bugs. Family Acanthiidæ.
- The Leaf-bugs. Family Capsidæ.
- The Red-bug Family. Family Pyrrhocoridæ.
- The Chinch-bug Family. Family Lygæidæ.
- The Stilt-bugs. Family Berytidæ.
- The Squash-bug Family. Family Coreidæ.

The Land-bugs with five-jointed antennæ.

- The Stink-bug Family. Family Pentatomidæ.
- The Burrower-bugs. Family Cydnidæ.
- The Negro-bugs. Family Corimælenidæ.
- The Shield-backed bugs. Family Scutelleridæ.

Many of these are of little interest to us and can be dismissed with a mere allusion.

Family Corisidæ (Water-boatmen). These are smallish insects, less than half an inch in length, and frequent pools, streams, and ponds. They are surrounded by a film of air and look like a bubble in the water, as they are seen usually on the bottoms. They are generally distributed over the United States, and are predaceous on other water insects. They have no economic importance with us, but in some parts of Mexico they are so numerous in the ponds that aquatic plants upon which they have deposited their eggs are gathered, dried, and beaten in order that the eggs may be secured for food.

Family Notonectidæ (Back-swimmers). These are aquatic bugs, their backs shaped like the bottom of a boat. They always swim on their backs, hence the common name. Their hind legs are oar-shaped, and they pass through the water with their aid with great rapidity. They prey upon young fish, and probably are destructive in this respect.

Family Nepidæ (Water-Scorpions). This is another of the aquatic bugs, and derives its common name from the possession of a long respiratory tube, at the end of the abdomen, which gives it a strong resemblance to the land-scorpion. There are two distinct types of these insects, one having an oval, flat, thin body, the other a linear and

cylindrical body. The latter strongly resembles a stick in the water, where it is usually found in the dirt of the bottom. The family is predaceous, and probably their peculiar form enables them to capture their prey.

Family *Belostomidæ* (Electric-light Bugs). In the hot summer nights, a very large insect will be seen flying around the electric lights in cities near watercourses or lakes. Many of these fall to the ground, where they are crushed under the heel of the pedestrian. These have become so noticeable since the introduction of electric lights that many people believe that they have been produced by the electricity, and their common name of "electric-light bugs" has been given them in recent years. These belong to the family *Belostomidæ*, which family



FIG. 41. Electric-light bug (*Belostoma americanum*).
Natural size.

includes the giants of the bug order. The common electric-light bug in our California towns will reach a length of two inches and is the *Belostoma americanum*, while in the tropics and in Mexico, specimens are common three to four inches in length. In their larval form they are wholly aquatic. Their eggs are attached to the stems of water plants or other convenient objects, and, as soon

as hatched, they commence their predatory career. They are exceedingly destructive to young fish, the young of frogs and toads, and other small game within their reach, which they capture by means of their strong fore feet and leisurely suck the blood. This insect is very numerous in Sacramento and in the valley where the great water areas furnish it ideal breeding grounds, and on summer nights they may be seen by thousands under the electric lights.

A peculiar member of this family is the genus *Zaitha*, in which the female lays her eggs on the back of the male, and he is compelled to carry them about and care for them until he is relieved of the load by their hatching. The male resents this indignity, but the female compels him to submit, and sometimes this is accomplished only after a struggle of several hours. In spite of protests and struggles, however, his better half always gets the best of the argument and he has to take care of the babies. It was at one time thought that the female laid the eggs

on her own back, but this belief was corrected by Miss Slater, who made a study of this insect. In speaking of it, this lady says: "That the male chafes under the burden is unmistakable; in fact, my suspicions as to the sex of the egg-carrier were first aroused by watching one in an aquarium which was trying to free itself from its load of eggs, an exhibition of a lack of maternal interest not to be expected in a female carrying her own eggs. Generally the *Zaithas* are very active, darting about with great rapidity; but an egg-bearer remains quietly clinging to a leaf with the end of the abdomen just out of the water. If attacked, he meekly receives the blows, seemingly preferring death, which, in several cases, was the result, to the indignity of carrying and caring for the eggs."

Family Naucoridæ (Creeping Water-bugs). These are rather small, flat-bodied, oval insects, predaceous in their habits, but not common on this coast, and of no economic importance.

Family Galgulidæ (Toad-shaped Bugs). These include a family of predaceous bugs only found near the margins of streams, and which are of no importance economically.

Family Salididæ (Shore-bugs). These are small, soft, dark-colored insects, with white or yellowish markings. Some are shiny black, but none of any importance to us.

Family Vellidæ (Broad-shouldered Water-striders). This is a small family of peculiarly shaped insects. Their legs are formed for running over the surface of water, but they can also travel on land with considerable speed.

Family Hydrobatidæ (Water-striders). The members of this family are well known to all who have ever observed insects skimming along over the surface of the water. Often they gather in large numbers, and, when disturbed, dart, with lightning-like rapidity, in all directions. They have no economic value, being neither good nor harmful.

Family Limnobatidæ (Marsh-treaders). There is but a single species of this family in the United States, and this is of no economic value.

Family Emesidæ (Thread-legged Bugs). This is a small family of very peculiar bugs. The body is long and slender and the middle and hind legs very long and thread-like. The fore legs are constructed for grasping, and resemble those of the praying mantis. It frequents trees, and is predaceous in its habits.

Family Reduviidæ (Assassin-bugs). We now come to a family of more interest to us, as in this are many of the most beneficial of the

bug family. The members of this family are all predaceous and voracious. They usually attack other insects and suck their juices, but the higher animals are not free from their attacks, and the kissing-bug belongs here. They have a very powerful beak, and can inflict a painful wound, if not carefully handled. One of the members of this family has a local reputation, and in the mountains it is known as the lumber-

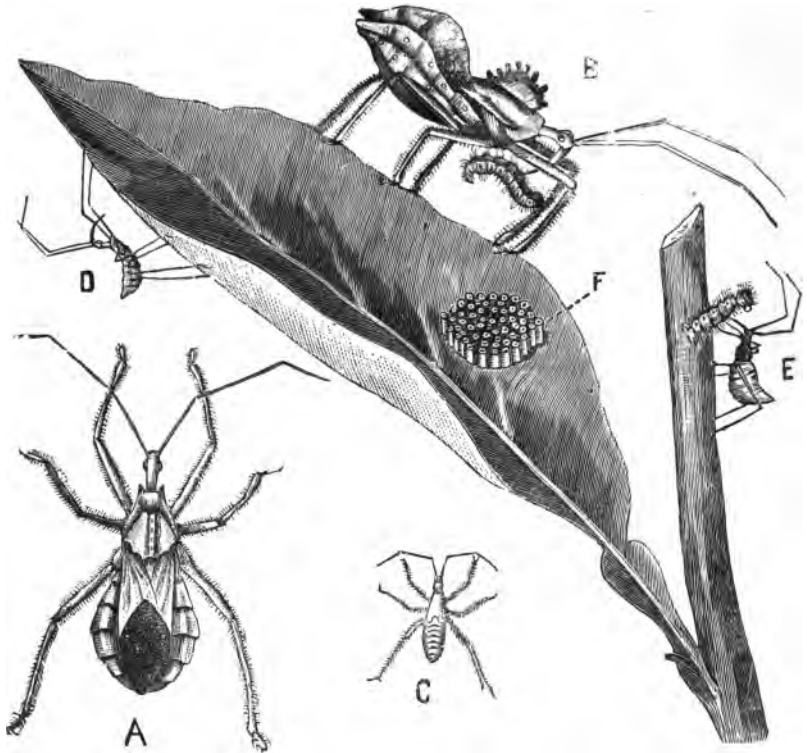


FIG. 42. Wheel-bug (*Prionidus cristatus*). A, adult insect; B, adult insect devouring a caterpillar; C, larva; D, larva; E, larva devouring a caterpillar; F, egg cluster. All enlarged.

man's bedbug. It is sometimes known as the Big Bedbug, and is the *Conorhinus sanguisugus*.

A peculiar member of this family is *Opsicætus personatus*, which, in its younger form, covers itself with particles of dust, and is coated even to the tips of its feet and antennæ. It enters houses and is an inveterate enemy of the bedbug, which it captures and sucks the blood from. From this habit it is known as the "Masked bedbug hunter." This mask is worn only during its immature stage; when fully developed it is about half an inch in length, and is one of about fifty members of this family known as kissing-bugs. It preys also upon flies and other insects. It has a very sharp beak, which it uses in its defense.

Another of the kissing-bugs, which appeared in large numbers in

California some years ago, is *Melanolestes picipes*. This insect is black, and is commonly found hiding beneath stones and boards. It can inflict a very painful wound.

The wheel-bug (*Prionidus cristatus*) is one of the most beneficial of the bug class, as it preys upon leaf-eating caterpillars, and does not hesitate to attack hairy worms, as the tussock-moths, fall web-worm, etc.

This is a large family, representing nine subfamilies and at least fifty genera. They are usually long, rakish-looking insects, with prominent, bulging eyes. The body color is generally dark-brown or black, although some of the members are lighter colored and in some cases beautifully marked. They have a three-jointed beak and are quick in their motions. Altogether the members of this family Reduviidæ or assassin-bugs may be regarded as friends of the fruit-grower, florist, and farmer, and should be protected, even at the expense of an occasional puncture from their beak.

Family Nabidæ (Damsel-bugs). This is a small family of predaceous insects. They generally hide among the blossoms and foliage of plants, where they prey upon small insects.

Family Phymatidæ (Ambush-bugs). These insects are called ambush bugs from their habit of concealing themselves and seizing their prey unawares. The most striking feature of this insect is in the peculiar form of the front legs, which are especially adapted for seizing and holding their prey. While a small insect, it will seize and hold an insect very much larger than itself, and will catch cabbage-worms, bees, and even wasps, and devour them.

Family Aradidæ (Flat-bugs). This family comprises the flattest of all the bugs. Its members live under the bark of decaying trees and in cracks where their flat bodies make it possible for them to creep.

Family Tingitidæ (Lace-bugs). This is a family of very small but very beautiful insects. Their common name is given on account of the beautiful lace-like markings of the wing covers, which are reticulated in a manner strongly resembling fine lace work. This insect is very common in California, where it attacks many plants and sometimes becomes so numerous as to seriously interfere with the health of the plant attacked.

Family Acanthiidæ (Bedbugs and Flower-bugs). The bedbug needs no description here. It is too well known, and no insect is more thoroughly detested. But there is a very close relation to this pest, which have wing covers fully developed and which are found on flowers and in other locations. They are predaceous, and are known as the flower-bugs.

Family **Capsidæ** (Leaf-bugs). This is the largest of any of the families of true bugs, including more than two hundred species in the United States alone. Most of the members live upon leaves of plants, but some of them are predaceous and prey upon other insects. In this family we find the tarnished plant-bug, the four-lined leaf-bug, and many other of our injurious species.

Family **Pyrrhocoridae** (Red-bugs). Insects belonging to this family are usually large in size, stoutly built and marked with strongly contrasting colors, in which red and black are conspicuous. The cotton-stainer is a member of this family, and has earned an unenviable notoriety from its habit of puncturing and discoloring the opening bolls of the cotton plant. This bug is a serious pest in Florida, where it pierces the rind of oranges, causing decay to set in.

Family **Lygaeidae** (Chinch-bugs). This is another large family, comprising nine subfamilies and a hundred and fifty species in the United States. The chinch-bug is the representative of the family, and probably the most destructive member of it. This is a rather small bug, but its destruction in the United States each year will run into many millions of dollars. It has two broods a year, and appears in enormous numbers, attacking the stems of grain and grass. While we have this insect in California, it has never been so destructive as in the Mississippi Valley, due probably to the custom which prevails here of burning over the stubble in the grain fields after harvest, by which means these insects are destroyed by millions and their increase prevented. In this family, too, we find the false chinch-bug, a very common insect here, and which somewhat resembles the true chinch-bug, but is never so numerous or destructive.



FIG. 43. Chinch-bug (*Blissus leucopterus*). Enlarged.

Family **Berytidae** (Stilt-bugs). This is a small family of land bugs, in which the legs, body, and antennæ are all very slender. They resemble the crane-fly in general build, and are found in the undergrowth of woods and pastures.

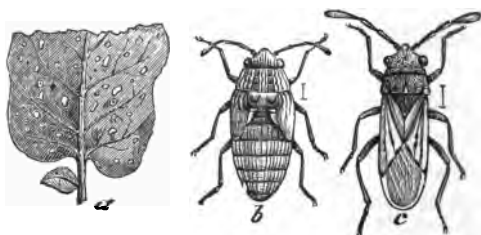


FIG. 44. False chinch-bug (*Nysius angustatus*). Enlarged.

Family **Coreidae** (Squash-bugs). This is another large family, and is divided into many subfamilies and species. The family comprises both carnivorous and vegetable-feeding forms, and in some cases

the same species will attack both animals and plants. A common species in our State is *Leptocoris trivittatus*, the box-elder bug.

Family Pentatomidæ (Stink-bugs). Every one who has lived in the country, and especially all our fruit-growers, is well acquainted with the stink-bugs, whose popular name is perhaps more descriptive than elegant. They are broad, flat bugs, generally rather large, and mostly dull colored. Most of them are vegetable feeders, although the family contains some predaceous species. One of the worst species of this family with us is the Harlequin cabbage-bug, which sometimes appears in great numbers, and does much damage to growing plants.

Family Cydnidæ (Burrowing-bugs). These bugs have a roundish, elliptical body, usually black, or very dark in color, and are found burrowing in sandy places, under sticks, stones, or near the roots or plants.

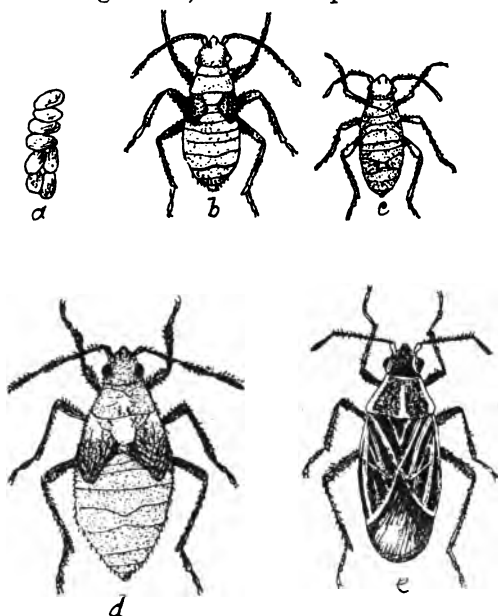


FIG. 45. Box-elder plant bug (*Leptocoris trivittatus*). a, eggs, enlarged; b, c, d, different stages of immature bugs, all enlarged. (After Howard.)

Family Corimelænidæ (Negro-bugs). These are small, black insects, and are sometimes found in quantity on blackberries, raspberries, and

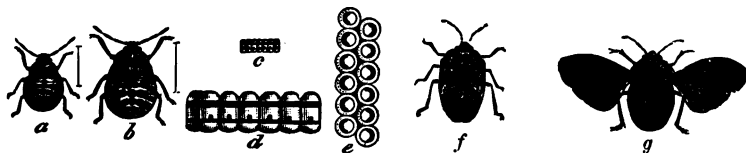


FIG. 46. Harlequin cabbage-bug (*Murgantia histrionica*). a, larva; b, pupa; c, eggs, natural size; d, eggs, enlarged; e, eggs, seen from above, enlarged; f, adult insect; g, adult insect, wings expanded.

strawberries. They do not confine themselves to these fruits, however, as they sometimes attack potato vines and do much damage.

Family Scutelleridæ (Shield-back bugs). This is not a numerous family. They are plant-eating insects, and somewhat resemble the negro-bugs in general appearance.

Suborder **HOMOPTERA**.

The name of this suborder is derived from two Greek words, *homos*, the same, and *pteron*, a wing. Its members differ from those of the other suborder in that the wings are of the same texture throughout, there being no difference in the two pairs of wings. The wings when at rest are usually sloping, like the roof of a house. They have no neck, the head being closely attached to the thorax, and this connection is so close that in many species the beak seems to exude from the thorax itself and to arise from between the fore legs. This suborder is divided into nine families, which are given by Comstock, as follows:

The Cicadas. Family Cicadidæ.

The Lantern-fly family. Family Fulgoridæ.

The Spittle Insects. Family Cercopidæ.

The Leaf-hoppers. Family Jassidæ.

The Tree-hoppers. Family Membracidæ.

The Jumping Plant-lice. Family Psyllidæ.

The Plant-lice. Family Aphididæ.

The Aleyrodes. Family Aleyrodidæ.

The Scale-bugs. Family Coccidæ.

In looking over this list, it will be noticed that here we have a great part of the more injurious pests of the farmer and fruit-grower. In fact, in the whole of this suborder there are not any that are not pests, and many of them the worst of the insect enemies with which we have to contend.

Professor Uhler, our authority in this order of insects, writes that "this grand division of the order contains the greatest number of large species, and the widest range of diversity in the forms of all stages. Comparatively few are destitute of wings, except in one sex of the lowest group; but some have these organs short and unfinished, and it is but very rarely that we meet with one of this kind fully winged. This division is also remarkable for the blunt face and backward pressed elements of the head and breast, thus carrying the rostrum far underneath. Both kinds of eyes are generally present; the compound ones being generally large and prominent, while the single ones, ocelli, are like little convex gems, placed between the larger eyes on the vertex or front, but occasionally, as in Fulgoridæ, on the sides of the cheeks, between the latter and the antennæ. There are usually two ocelli, although in Cicadidæ and most Psyllidæ they are three in number and are placed in front, forming a triangle. The antennæ are usually situated in the hollow between the eyes, and are composed of a few expanded joints at the base, with a tapering, slender, bristle-shaped termination. Exceptions occur in Psyllidæ, Aphididæ, and Coccidæ,

where these organs are commonly filiform and somewhat thickened at the tip. There are two principal types of legs in this division, although these are variously modified for particular modes of life, the one being adapted for crawling, the other for leaping. The former have short legs, generally stout; the latter have the hind legs long, often curved and set with rows of stiff spines."

Family Cicadidæ. This includes the harvest-flies, seventeen-year locusts, etc. These insects are of large size, and are generally well known. This family has a peculiarity found in no other member of the Hemiptera: the possession of a musical apparatus. The song of the cicada is well known, and is produced by special organs consisting of two large parchment sacs. The surfaces are ribbed and, when in action, the air is forced against these ribbed surfaces, producing sound vibrations and forming the song. It is probable that this "song" is used for the purpose of attracting the female, as these organs are found in the male only. This fact was known to the ancients and an old Greek, Xenarchos, says:

"Happy the cicadas' lives,
For they all have voiceless wives."

The females deposit their eggs in slits which they make in the twigs of trees; these eggs hatch in about six weeks and the young drop to the ground and bury themselves in the earth, where they are supposed to attach themselves to the roots of trees and shrubs, and where they remain until they reach their mature stage, when they force their way from the earth and attach themselves to any convenient object. Here the back of the pupa skin splits and the mature insect, fully winged, creeps forth. It requires some little time for its wings to fully develop, when the newly hatched cicada takes flight to start a new cycle.

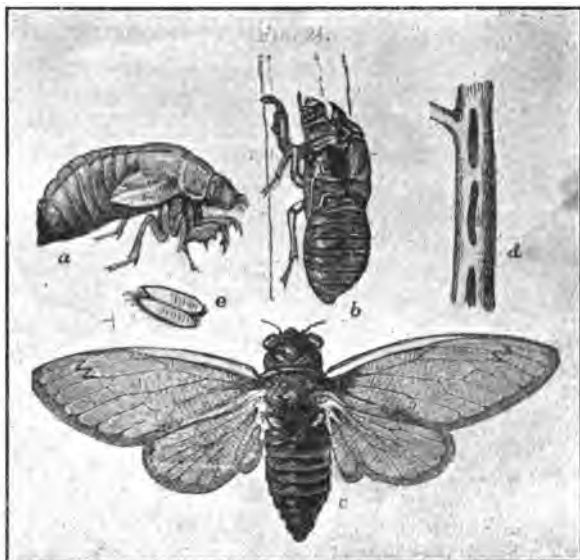


FIG. 47. Periodical cicada (*C. septendecim*). a, pupa, ready to change; b, pupa skin from which the adult (c) has emerged; e, eggs taken from the egg-punctures (d).

The most remarkable thing connected with this family is the length of the larval stage of the two members, known as "Seventeen-year" and "Thirteen-year" locusts. These broods have been watched and recorded by entomologists, and, in one case, they are known to appear in seventeen and in the other in thirteen years. It is, therefore, supposed that their larval, or growing, stage requires seventeen and thirteen years respectively. This is a most remarkable thing in the insect world, as most of these animals have lives of short duration, rarely covering a longer period than a year or two, though this is exceeded in a few instances. But a seventeen-year-old insect is a phenomenon that might be doubted, were it not that the records have been accurately kept and prove it.

Family Fulgoridæ (Lantern-flies). In the tropics of South America, members of this family attain great size and are phosphorescent, from which fact we have their common name. The family is represented with us by some small and insignificant species.

Family Cercopidæ (Spittle-bugs, Frog-hoppers, etc.). Often during the summer months one will notice masses of froth on shrubbery; upon removing this, a small, soft-bodied insect will be discovered beneath it. Sometimes there will be two or more of these insects under



FIG. 48. Frog-hopper or spittle insect (*Aphrophora* sp.). Slightly enlarged.

one mass of froth. These are the spittle-bugs, and the froth, which is composed of the sap of the bush upon which they are lodged and which is pumped out by them, is their means of protection. Clear this away a few times and keep the insect clear of it, and it will dry up and die. At its last molt, a clear space under the froth is

formed, and the mature insect, no longer needing the moisture for its safety, emerges a perfect frog-hopper, and wanders about the plant.

This is quite a large family, and includes a number of species. All are injurious, where they appear in numbers, as they exist by sucking the juices of the plants upon which they lodge.

Family Jassidæ (Leaf-hoppers). This is a family of insects, generally small in size, but very destructive. In this family is *Erythoneura vitis*, the grapevine leaf-hopper, which has a most unfavorable reputation in the raisin vineyards of this State, where it is commonly known as "thrips," although it is not at all related to that insect. During the summer season, they sometimes appear in the vineyards by millions, and by sucking the juices of the vines through the leaves do immense damage. These insects hibernate in the vineyards or vicinity, and

under leaves or rubbish, and the best preventive method to be applied against them is to thoroughly clean the vineyard and its neighborhood of all loose rubbish and burn it. By this means the next season's crop of the pest can be greatly reduced.

They are very destructive in meadows, and it is stated that these insects destroy from one fourth to one half of the grass that springs up annually. They are more numerous than any other insect, except, perhaps, the aphids.

Family **Membracidae** (Tree-hoppers). In this family we find some of the most grotesque forms in the animal kingdom. This is the typical family of the suborder Homoptera. Its members are of every conceivable form, and are described by Prof. Otto Lugger as "arched, compressed, depressed, hump-backed, spindle-shaped, pointed at both ends, inflated, hemispherical or conical, and besides this they are furnished with an endless variety of superficial attachments." They live principally on trees and bushes, and all possess great leaping powers, hence their common name. They are usually not sufficiently numerous to be destructive and have therefore little economic value.



FIG. 49. Buffalo tree-hopper (*Cercsa bubalus*).

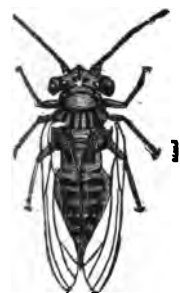


FIG. 50. Pear-tree Psylla (*Psylla pyricola*). Enlarged.

in being of a more solid texture, with stouter legs, the hinder pair being especially strong and fitted for jumping. In their adult form, both sexes are winged. A peculiarity in some of the species of this family is the bifurcated antennae. In these the feelers are split and end in two bristle-like points. Some of these species exude a honey-dew, and in this respect approach the aphids.

The commonest and most destructive member of this family is the pear-tree Psylla (*Psylla pyricola*). This is a

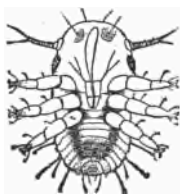


FIG. 51. Larva of *Psylla pyricola*. Enlarged.

very small insect, not over a sixteenth of an inch in length, but it often occurs in such quantities as to do enormous damage to the pear orchards.

Family **Aphididae** (Plant-lice). This family is closely akin to the foregoing, and in some of its many species is known to nearly every one; to all who have endeavored to grow flowers or vegetables, or who have noticed trees at all. It is a very extensive family, and includes

many species, some of which attack most forms of vegetation. In this family we have the phylloxera and the woolly-aphis, and many other well-known forms, all exceedingly destructive to vegetation. The largest species is about a quarter of an inch in length, and from this they range down until it requires a good eye, sometimes assisted by a magnifying glass, to see the smaller members. Some are subterranean,

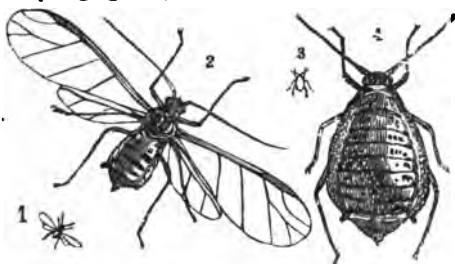


FIG. 52. Aphids or plant lice. Winged and wingless forms. 1 and 3 natural size. 2 and 4 greatly enlarged.

living wholly underground; some are aërial, living on the tops of plants; while some are both, and pass one stage of their existence underground and another above.

Insects belonging to this family are soft-bodied, gregarious, and most numerous in the wingless form. They have absolutely no means of defense, being destroyed by thousands by every

change in the weather, blown to destruction by the winds and washed off by the rains. They have more enemies among predaceous insects than has any other family, being preyed upon in all stages by the lady-birds, which devour them externally, and by Braconids, which devour them from the inside. Many birds eat them, and, being utterly defenseless, they are beset by enemies on every hand. Why, then, are they not exterminated? For the reason that nature has made them so enormously prolific that they are enabled to withstand all the destructive forces which are at work against them, and still leave enough for a new start, for if but a single one is left, that is enough to stock the country with a new brood.

The aphis furnishes the most interesting study in the entomological world. It is a contradiction of all known laws in relation to propagation. The first brood, which appears very early in the spring, as soon as there is sufficient plant life to sustain it, is hatched from eggs which have been previously deposited in the crevices of the bark. These are all females. They commence the active work of their lives at once, and suck the plant juices and grow, casting their skin, as they become too large for it, about four times, by which time they have reached adult size and are ready to begin the second great object of their life—that of propagation.

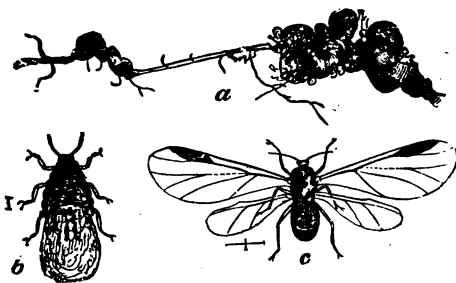


FIG. 53. Woolly aphis of apple (*Schizoneura lanigera*). Enlarged.

These females give birth to new broods, all of which are still females, and only females are born. This peculiar propagation is continued throughout the summer. In the autumn, however, when the weather grows colder, the last births are both male and female, and these last born females only lay eggs, which remain dormant until the following spring, when they hatch out females, and the same process continues without end.

Some naturalists hold that if the conditions are right the aphid will continue to give birth to females indefinitely without the presence of males. Kyber records having had a rose aphid which produced young for four years, and from his careful experiments it has been asserted that under certain circumstances a female aphid may, in the entire absence of males, continue propagating to infinity, providing that the necessary conditions—food and heat—for the development of the young are not wanting.

The color of the eggs of the aphid, together with their rarity, makes them difficult to discover. During the months of February and March, when the leaf buds of the rose begin to swell, the eggs of the rose aphid may be seen like grains of gunpowder fixed within the crevices of the bark. A single insect hatched from one of those shining black eggs may be the progenitor of many billions of young during her lifetime. Latrielle, who is an authority on this branch of entomology, makes a curious calculation. He says that one female will produce young at the rate of about twenty-five a day during the summer months, and one aphid may be the mother of the enormous number of 5,904,000,000 during the month or six weeks of her existence. Tongard and Morren, equally good authorities, extend this number into quintillions, as being within the capabilities of a single mother's efforts. Professor Huxley makes a calculation which affords an approximate idea of what a quintillion of aphids might mean. Assuming that an aphid weighs as little as the one-thousandth part of a grain, and that it requires a man to be very stout to weigh more than two million grains, he shows that the tenth brood of aphids alone, without adding the products of all the generations which precede the tenth, if all the members survive the perils to which they are exposed, contains more ponderable substance than five hundred million stout men; that is, more than the whole population of China and the United States combined. Fortunately there are large numbers of carnivorous insects which prey upon the aphids and prevent their inordinate increase. The variations in temperature, winds, and birds also have a tendency to prevent their too rapid spread.

We have alluded to the fact that some species of aphids are subterranean, passing their entire existence underground. Among these are the Rhizobiinæ, which are found on the roots of shrubs and plants, and may be very injurious. These never come to the surface, are wingless, and seem to be cared for by ants, which aid in their distribution.

Another underground form is the dreaded *Phylloxera vastatrix*. This pest is known all over the world and has caused millions upon millions of dollars' loss by its depredations in the vineyards of Europe and America. The life history of this pest is given by Professor Marlatt, as follows:

"The life cycle of the phylloxera is a complicated one. It occurs in four forms in the following order: The leaf-gall form (*gallicola*), the root or destructive form (*radicicola*), the winged or colonizing form, and the sexual form. The leaf-gall insect produces from 500 to 600 eggs for each individual, the root-inhabiting insect not much above 100 eggs, the winged insect from 3 to 8, and the last sexed insect but one egg. This last is the winter egg, and may be taken as a starting point of the life cycle. It is laid in the fall on the old wood, and hatches, the spring following, into a louse, which goes at once to a young leaf, in the upper surface of which it inserts its beak. The sucking and irritation soon cause a depression to form about the young louse, which grows into a gall projecting on the lower side of the leaf. In about fifteen days the louse becomes a plump, orange-yellow, full-grown, wingless female, and fills its gall with small yellow eggs, dying soon after. The eggs hatch in about eight days into young females again, like the parent, and migrate to all parts of the vine to form new galls. Six or seven generations of these wingless females follow one another throughout the summer, frequently completely studding the leaves with galls. With the approach of cold weather the young pass down the vines to the roots, where they remain dormant until spring. The root is then attacked, and a series of subterranean generations of wingless females is developed. The root form differs but slightly from the inhabitant of the leaf galls, and the swellings or excrescences on the roots are analogous to those on the leaves.

"During late summer and fall of the second year some of the root lice give rise to winged females, which escape through cracks in the soil, on warm, bright days and fly to neighboring vines. These winged lice lay their eggs within a day or two in groups of two or four in cracks in the bark or beneath loose bark on the old wood of the vine, and die soon after. The eggs are of two sizes, the smaller and fewer in number yielding males in nine or ten days, and the larger the females of the only sexed generation developed in the whole life round of the insect. In this last and sexed stage, the mouth parts of both sexes are rudimentary, and no food at all is taken. The insect is very minute, and resembles the newly hatched louse of either the gall or the root form. The single egg of the larva-like female after fertilization rapidly increases in size until it fills the entire body of the mother, and is laid within three or four days, bringing us back to the winter egg, or starting point.

"This two-year life round is not necessary to the existence of the species, and the root form may and generally does go on in successive broods year after year, as in the case with European vines, on the leaves of which galls rarely occur. Under exceptional circumstances all of the different stages may be passed through in a single year. The young from leaf galls may also be easily colonized on the roots, and it is probable that the passage of the young from the leaves to the roots may take place at any time during the summer. The reverse of this process, or the migration of the young directly from the roots to the leaves, has never been observed."

We have dealt somewhat extendedly with the aphids, because they are among the most serious pests of the farmer and fruit-grower in our own State, as they are elsewhere in the Union.

Family Aleyrodidæ. In the aleyrodes we have a connecting link between the aphids and the scale insects. In the early stages of their lives, the larval form, the aleyrodes are true scale-bugs, and very strongly resemble certain species of *Lecaniums*. For a long time, members of this family were classed with the Coccids, but owing to very marked differences in the mature insects were erected into a separate family. They are very small insects, and in the larval form are sometimes quite pretty, having a dark center and being surrounded by a fringe of white, waxy filaments. In the mature stage, both sexes are winged, herein differing from the Coccidæ, in which only the male acquires wings. In this

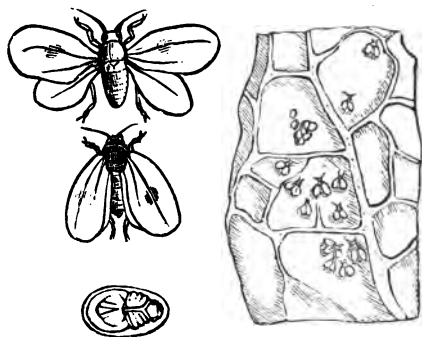


FIG. 54. White flies (*Aleyrodes* sp.). Natural size and enlarged.

stage they are small, white, four-winged flies, very strongly resembling minute moths. The wings and bodies are covered with a whitish powder, resembling flour. We have several species of this family in California, and they may be found quite commonly on the under side of the leaves of fuchsias, nettles, iris, and other plants. Where very numerous, they fly off in a white cloud like a cloud of dust when disturbed. None of our native species are especially injurious, but in Florida and other of the Southern states the *Aleyrodes citri* (the white fly), a species found upon citrus fruits, has proven a very destructive and dangerous pest and one that it has not been found possible to control.

Family Coccidæ (Scale-bugs, Mealy-bugs, etc.). We now come to a family more widely known, and, in California, more generally destructive than any other of the insect tribe. It is a very large family,

including something over fifteen hundred species, not all of which, however, are found in California.

The family Coccidæ is divided into nine subfamilies, each having its peculiarities of form and habits, which are set forth as follows:

Subfamily **Monophlebinae**. Of this subfamily, which comprises ten genera, we have a good representative in *Icerya purchasi* (the cottony-cushion scale), which is well known to almost every horticulturist in California. The general characteristics are: Males with compound eyes. Females with definite hairy anal ring. The insects are usually covered by a cottony matter of several shades of color and with a secretion of still longer filaments. Skin with rounded spinnerets and with long, scattered hairs. The lateral lobes of the extremity of the abdomen are fitted with a series of long, interlaced bristles.

Subfamily **Margarodinae**. This subfamily has been erected to accommodate a single genus—*Margarodius*—comprising about ten species. This subfamily is not represented in California. One very pretty species is found infesting roots in South Africa and is bead-shaped. They are very brilliant in color, being somewhat of a metallic green, and are collected by the natives, strung on stout thread and worn as ornaments.

Subfamily **Ortheziinae**. Under this subfamily are included three genera, of which the genus *Orthezia* is the most important and the only one represented in California. The female presents the following characters: Eyes simple, anal ring with hairs. Body more or less covered with cereous matter arranged in compact symmetrical plates. The eggs are carried in an elongated ovisac, which projects behind the body until they hatch. Insect active throughout entire life. Legs long, with fine hairs, one claw, and no digitules. Two or more long, slender, snow-white filaments project from near the posterior end. Color usually white.

Subfamily **Phenacoleachinae**. This subfamily was erected to accommodate a single genus—*Phenacoleachia*—and is represented by a single species, which occurs in New Zealand on *Cupressus* sp.

Subfamily **Conchaspinae**. These are insects with a separate covering scale, which is formed entirely of secretory matter, not using the cast skins (exuviae) in forming the covering scale. Adult females retain limbs and antennae. A distinguishing feature of this subfamily is to be found in the mouth parts, as the lower part of the mouth (mentum) is composed of two parts, and is grooved out to accommodate the sucking tube of the insect. This subfamily contains but a single genus—*Conchaspis*—of which only four species have been recorded, none of which occur in California.

Subfamily Dactylopiinæ. This subfamily includes a large number of genera, something like fifty-two, of which thirteen occur in California. Among those found in this State are the following: *Asterolecanium*, *Pollinia*, *Kermes*, *Nidularia*, *Gossyparia*, *Eriococcus*, *Dactylopius*, *Ceroputo*, *Pseudococcus*, *Erium*, *Ripersia*, and *Antonina*. The most important of these is the *Pseudococcus* (mealy-bugs). The following may be of assistance in placing the species in their proper place: Abdominal extremity not cleft, usually with a pair of more or less prominent rounded tubercles, each bearing a long seta. No hinged plates above anal orifice. Larva with abdominal lobes. Female not secreting a waxy scale.

Subfamily Tachardiiinæ. These insects are inclosed in a resinous cell, with three orifices. Adult female without legs, with the terminal segments produced into a tail-like organ, with the anal orifice at the extremity, which is surrounded by a broken hairy ring. A spine-like organ above the base of the caudal extension. This subfamily includes but two genera, comprising about twenty-three species, and is not represented in California.

Subfamily Coccinæ. This is another large subfamily, embracing some forty-eight genera, ten of which are represented in California, viz.: *Pulvinaria*, *Exæretopus*, *Ceroplastes*, *Vinsonia*, *Eucalymanatus*, *Coccus*, *Eulecanium*, *Saissetia*, *Physokermes*, and *Aclerda*. The main characters of the Coccinæ are as follows: Females keeping the form of the body, with segments distinct until the end, and also retaining the power of moving under certain circumstances while young. Either naked or simply covered with waxy filamentary material. Most of the females, after impregnation, take on a different form and become fixed to the host plant, and, once fixed, remain so for the rest of their lives. Under this subfamily are grouped some of the more destructive forms with which the fruit-growers of California have to contend. The principal ones being *Saissetia oleæ* (black scale), *Pulvinaria innumerabilis* (cottony maple scale), and *Coccus hesperidum* (soft orange scale), although this species is now not considered a pest.

Subfamily Diaspinæ. These insects have a separate covering-scale composed partly of secretionary matter and partly of the exuviae, which are the discarded skins shed at the periodical molts of the insect. Adult female without limbs. The form of the scales comprising this family are usually circular, varying to oblong. The eggs are deposited beneath the parent scale. Under this subfamily occur some thirty-five genera, among which are to be found many of the most destructive species in our State. The principal ones are *Chionaspis*, *Diaspis*, *Aulacaspis*, *Hemichionaspis*, *Fiorinia*, *Aspidiotus*, *Chrysomphalus*, *Pseudaonidia*, *Lepidosaphes*, and *Parlatoria*.

In treating of the different species of the scale-bug family, it will be well to call attention to the new classification. Our Horticultural Commissioners have struggled hard, in most cases, to inform themselves in regard to scale pests in California, and have learned to know them by their old names. Now, these names have been largely changed, the knowledge acquired by our commissioners is turned topsy-turvy, and they will have to learn the names of their old acquaintances over again, or fail to recognize them when they appear in print. Following is appended a list of the changes which have been made in the nomenclature of the more common of our California scales.

<i>Common Name.</i>	<i>New Name.</i>	<i>Old Name.</i>
Mealy-Bug.	Pseudococcus.	Dactylopius.
Black Scale.	Saissetia oleæ.	Lecanium oleæ.
Soft Brown Scale.	Coccus hesperidum.	Lecanium hesperidum.
Hemispherical Scale.	Saissetia hemispherica.	Lecanium hemisphericum.
Apricot Scale.	Eulecanium armeniacum.	Lecanium armeniacum.
Frosted Scale (Prune Scale).	Eulecanium pruinsum.	Lecanium pruinsum.
Red Scale.	Chrysomphalus aurantii.	Aspidiotus aurantii.
Yellow Scale.	Chrysomphalus citrinus.	Aspidiotus citrinus.
Oleander Scale.	Aspidiotus hedere.	Aspidiotus nerii.
Purple Scale.	Lepidosaphes beckii.	Mytilaspis citricola.
Long Scale.	Lepidosaphes gloverii.	Mytilaspis gloverii.
Rose Scale.	Aulacaspis rosæ.	Diaspis rosæ.

These are a few of the changes that have been made in the nomenclature of this family, and the list presented above will aid our commissioners and those who learned under the old school to recognize their old friends under their new names.

In many members of this family there seems to be a sort of retrogression, and they go from bad to worse, from the time they are hatched out until they die. When first hatched they are perfectly formed insects, having the required six legs, well-formed antennæ, eyes, and mouth parts. They are lively in their motions and get around at a fairly good rate. In a short time, however, they settle down in a chosen place, on some form of vegetable, insert their beak and suck. Having no further use for legs and other organs needed in active life, they gradually lose them, molting in the meantime, and forming the coating which we know as a scale. In the last stage, however, there is a difference between the two sexes, for while the female never changes her position, being converted as it were into a mass of eggs and young at the end of her life, the male emerges from the scale form a perfect insect; usually a very pretty little creature, with a full complement of feet and wings, and all other organs except mouth parts. He can no longer eat, and is therefore not to be feared. His mouth parts disappear and in their places he acquires a new pair of eyes. This we presume is the better to enable him to find the female, for this is now all that is left in life for him, and he soon passes away.

This description will hardly apply to members of several of the sub-families, in which both sexes retain some powers of locomotion through life and do not become fixed, nor form a scale. A peculiarity of this family, too, is that while they belong to the four-winged insects, the perfect males have but one pair of wings, a pair of small hooks, known as halteres or poisers, taking the place of the other pair, and, unlike other members of this order, the males undergo a complete metamorphosis.

As the Coccidæ are treated of *in extenso* in another publication issued by the Commission of Horticulture, under the title of "The Coccidæ of California," we will dismiss this family here, and refer our readers thereto for a full account of them.

Order **NEUROPTERA.**

(The Nerve-winged Insects.)

In the old classification, this order included all insects with four more or less transparent wings, and these veined or netted. The lace-winged fly and the dragon-fly were marked types of the order. In all members the mouth parts are formed for biting. Aside from the winged resemblance, however, there were such marked differences in the diverse members of this order that several new orders have been constructed from it, and it is divided into from two to five minor orders, according to the importance attached by authorities to the development of different organs, and especially in relation to different methods of transformation. This order, or group of orders, is not of great importance to us, for aside from some beneficial insects which we find in it, the greater portion are neither beneficial nor injurious; we may therefore consider its members together under the old style.

In this order both pairs of wings are usually of the same size and of a similar membranous texture, and traversed with nervures, which are usually united by a number of smaller ones, so that the wings present a net-like appearance. In some of the members the metamorphosis is complete and in others incomplete, and upon this fact the order has been divided. The Neuroptera proper are divided into seven families: Mantispidæ, Raphidiidæ, Sialidæ, Coniopterygidæ, Myrmeleonidæ, Hemerobiidæ, and Chrysopidæ.

The family **Mantispidæ** is so named from the fact that the insects strongly resemble the praying mantis in the order Hemiptera. They are much smaller insects, however, and their possession of four strongly marked membranous wings gives them a place in the order under discussion. They have strong, grasping forelegs and are predaceous, living upon other insects. Only one member of this family is known in California, *Symphasis signata*, but it is not frequently met with.

The family **Raphidiidæ** is represented in California by an insect about half an inch in length, with a peculiarly shaped head and neck which protrude far in advance of the wings. It is a predaceous insect, lives largely on the larvæ of the codling-moth, and is one of the best of the native parasites of this pest. It is not a common insect, but is sometimes found under the bark of trees, where it takes refuge.

The family **Contiopterygidæ** comprises a few rare insects which have no economic importance, and are of interest only to the systematist.

The family **Sialidæ** includes the Dobson fly, which, in its larval form, serves as a bait for anglers. In this stage it is an aquatic insect, living upon other water insects. It has no economic value.

The family **Myrmeleonidæ** are the doodle-bugs, or ant-lions. They have the peculiar habit of setting a trap for their prey, usually in the path of the ants, and this they do by digging a pit in the shifting sand. When an ant gets over the edge of this pit he rolls to the bottom, where the doodle-bug grasps him in his jaws and sucks out the juices. In their matured form they strongly resemble dragon-flies.

The family **Hemerobidæ** strongly resembles the lace-winged flies in appearance, but much larger and differently colored, being usually dark brown. They are predaceous, and, so far, beneficial.

The family **Chrysopidæ** includes the lace-winged flies, so well known to our orchardists. In their larval form they are commonly known as aphid-lions, from the fact that they are largely predaceous on aphids. The mature insect is a very pretty creature, with its delicate form, gauzy wings, and brilliant, prominent golden eyes. Upon being dis-

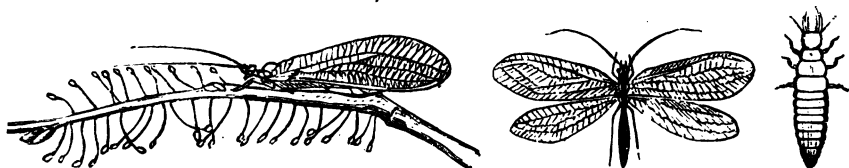


FIG. 55. Lace-winged fly.

turbed they emit a disagreeable fetid odor. Their eggs are white, are supported on long stalks, and are usually deposited on plants infested with aphids. The larvæ are active and extremely voracious. There are two or more broods during the summer, and the last brood winters in the pupa state protected by a compact, round, whitish cocoon.

There has been much confusion among entomologists in regard to the insects comprising this order, owing to the diversity of character of many of the insects classified under it originally, and this has resulted

in splitting it up into several minor orders, some of which are represented by a single family. Some authorities divide it into two sub-orders, the true Neuroptera and the Pseudo-neuroptera. In the former the metamorphosis is complete, and in the latter it is incomplete. In this classification of Neuroptera and Pseudo-neuroptera, the insects with incomplete metamorphosis are separated into *Ephemeroptera*, or mayflies; *Odonata*, or dragon-flies; *Plectoptera*, or stone-flies; *Platyptera*, the white ants, book-lice, and bird-lice. Comstock, however, erects separate orders for these, and does not recognize the Pseudo-neuroptera. As few of these are of great economic importance, and as this is not a scientific treatise, we give the minor orders place under the general title of Neuroptera.

Order **Mecoptera** includes but one family, the scorpion-flies, so-called because the last abdominal segment has a strong resemblance to the sting of the scorpion. It is not a sting, however, and contains only a set of grasping organs. These insects are of no economic importance.

Order **Trichoptera**, the caddice flies, in their larval stage, are found in streams and have the peculiarity of constructing for themselves shelters of particles of wood, gravel, and other substances. The larvæ remain in these structures, the head alone protruding, and are thus safe from outside foes. The material of which these structures are joined together is a silk spun by the worm, and the inside of the tubes is generally lined with the same substance. Another peculiarity of these insects is that under water they construct a web very similar to that of the spider on the surface.

Order **Ephemerida** includes the mayflies, which are very delicate insects that appear in enormous numbers on summer evenings on the margins of quiet streams and lakes. The mayfly is an aquatic insect, and spends its entire larval life in the water. In its perfect form it is a beautiful sprite-like insect, without mouth parts, its only object in life being to lay the eggs which are to produce a new generation. This is accomplished in a few hours and the insect passes away. They have no economic value. The metamorphosis is incomplete.

Order **Odonata** (Dragon-flies). Members of this order are easily recognized and are well known. They are, in their larval form, aquatic, and have an incomplete metamorphosis. They may be classed as beneficial, as they live almost wholly on mosquitoes in both their larval and mature stages, and are probably one of nature's most effective methods of keeping down these troublesome pests. Unfortunately, this insect has been credited with malign powers, and ignorant people regard it as a dangerous insect. It is at once one of the most graceful,

beautiful, useful, and harmless of the insect tribe. It has no sting and no means of defense, except in its rapid flight, and may be handled with impunity by collectors. Aside from their work on mosquitoes, members of this order have no interest to our orchardists.



FIG. 56. Dragon-fly. Natural size.

Order Plecoptera (Stone-flies). These are insects having an incomplete metamorphosis, and which breed in great numbers in streams. They are known as stone-flies from the fact that they take refuge under stones in the streams, and are a favorite bait with anglers. Fish are very fond of them, but aside from this they are of no economic importance.

Order Isoptera includes the so-called white ants, or termites, which, by the way, are not ants at all, nor even remotely connected with them. Termites are very common insects in California, where they will be

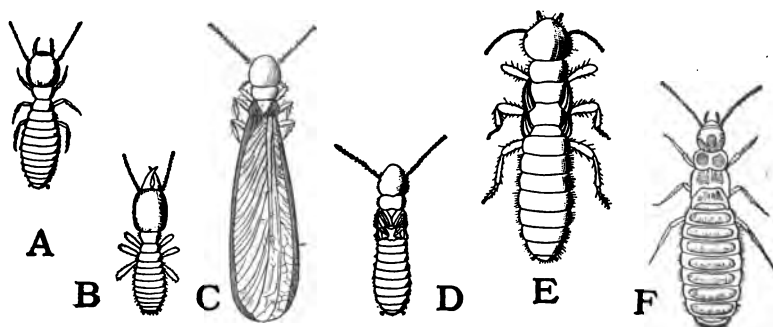


FIG. 57. Various forms of *Termes lucifugus*. A, adult worker; B, soldier; C, perfect winged insect; D, perfect insect after shedding the wings; E, young complementary queen; F, older complementary queen. Enlarged. (After Grassi and Sandias.)

found working usually on decaying wood, but sometimes attacking growing trees just beneath the surface of the ground. They are not, however, seriously harmful, and while some damage is reported from their attacks, this is not common. This order comprises some of the most remarkable and interesting forms of insect life, and it may be well to

deal more extensively with it. There are seven species found in the United States, of which four are confined to the Pacific Coast. None of these are of large size, usually being from one sixth to one fourth of an inch long. In the tropics, however, they attain a much larger size, and are among the most destructive of insects, in some cases being so destructive to wood that this material can be used very sparingly, if at all, in buildings. Comstock gives the following account of the life of the termites:

"A remarkable thing about the white ants is the way they are divided into classes, each class fitted to do a certain work for the colony. *First*, there is the class of workers, which is constituted of both sexes; they are wingless and of a dirty-white color, and while they resemble true ants somewhat, their waists are thicker. Their business is to bring food for everybody, feed and bring up the young termites, and build nests. *Second*, there is the class called soldiers; these, too, are of both sexes, and wingless, and look somewhat like the workers, only their heads are tremendous in size, being often nearly as long as the rest of the body, and their jaws are large and powerful. *Third*, is the royal class, called *kings* and *queens*. It would have been better to have called them fathers and mothers, as they are the parents of the colony, and do not rule it. This class when grown have wings, which lie flat upon the back when at rest, and may be twice as long as the body. In May or June in our common species this class swarms forth from all the nests of the neighborhood. After a flight of some distance the wings are shed, and a king chooses some queen near him and proposes that they start a kingdom of their own. But like mortal kings and queens they can not reign unless a kingdom is found for them, and so millions of these royal pairs die because they have no subjects. But sometimes a fortunate couple is discovered by some termite workers, who at once take possession of the wanderers and provide them with food and with shelter in the shape of a large circular shallow cell. In this they are really imprisoned, but are well cared for. Soon the queen or mother begins to develop eggs, and her body grows enormously. Finally, it is nothing but a huge sac filled with eggs, looking more like a potato than anything else, and is sometimes six or seven inches long. Of course, the poor queen can not move herself in the least, and if she were not fed would soon starve; but her king remains devoted to her, and her ladies and gentlemen in waiting do their best to make her comfortable; they carry away the eggs to other chambers as soon as they are laid, then care for the eggs, and feed the little ones when they are hatched. The young termites are active, and resemble the adult in form. If a nest becomes queenless, and the workers are unable to procure a queen, there are developed in the nest wingless sexual individuals, which are termed complemental males and females. But as each

complemental female lays only a few eggs, it requires several to take the place of a real queen.

"All white ants are miners, and avoid the light. They build covered ways wherever they wish to go. In hot countries they are a terrible pest, as they feed upon wood, and actually destroy buildings and furniture and libraries. They leave merely the outside portion of what they feed upon; and they have been known to enter a table through the bottom of the legs and to eat all the inner portions so that a slight weight crushed it to the floor. In Florida they do damage to orange and other trees by girdling them below the surface of the ground."

Order Corrodentia (Book-lice, etc.). These are tiny creatures, somewhat resembling the termites in appearance, only one family of which, the Psocids, are found in the United States. They are general scavengers and receive their common name of book-lice from the fact that they are sometimes found in libraries, attacking old and unused books. They are found in great numbers in many of our orchards, where they congregate in colonies. They lay their eggs in heaps on leaves and branches, and cover them with a web, giving vegetation a dirty appearance, as the dust finds lodgment on these webs. The dry climate of California is especially favorable to their propagation, but, aside from the fact that they give our trees a dirty appearance, they are of no importance to us from an economic standpoint.

Order Malophaga. This order has been erected for the bird-lice. We have alluded to these insects before, and little more need be said of them.* They infest birds and sometimes are also found on animals,

being known by the name "wool-eaters," which was given them because some species are found on sheep and goats. They are furnished with 'mandibulate jaws, and are, therefore, biting and not sucking insects. In this they differ from the true lice, which are suckers. Their metamorphosis is incomplete.

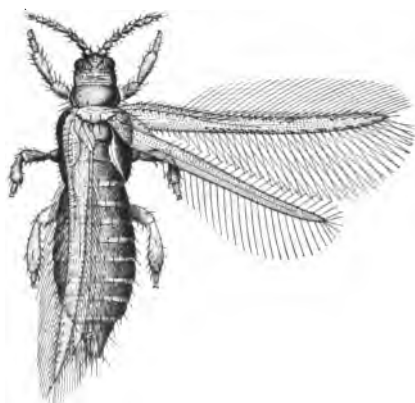


FIG. 58. Pear-thrips (*Euthrips pyrf*). Greatly enlarged.

Order Physopoda (Thrips). This is a small order of very small insects which has had a deal of trouble in getting located. Entomologists have located it in the Hemiptera, the Orthoptera, and the Neuroptera. Finally a "Thysanoptera" was created to take care of it,

and now it has come to be known as Physopoda. Whatever the name

of this group, its members while exceedingly minute are also exceedingly destructive. The various species in this order are distinctly different from those belonging to any other order, which accounts for the trouble of locating them when there were only the seven orders in which to place all insects, and the necessity at last of erecting an order for them.

These insects abound in flowers and flowering plants and can be found in great quantities in many blossoms. In some sections they infest pear, orange, and other fruit trees, and do much damage by injuring the blossoms, as they bite into the essential organs and prevent the fruit blooms from fertilizing and the fruit from setting. In the vineyards of this State one of the leaf-hoppers is called a thrips, but this is a misnomer, as the insect found in the vineyard is a hopper, and belongs to the Homoptera.

Order **LEPIDOPTERA.**

(Butterflies and Moths.)

A description of the members of this order is hardly necessary, as it is the best known of all the insect tribe. The butterflies are especially attractive to the non-scientific classes, as they comprise the most attractive and showy of all insects. We find them of all colors and all combinations of color, and of such varied forms that one becomes bewildered with their myriad beauties. They have been aptly termed the flowers of the insect world, and, certainly, in their varied hues and forms, they more resemble flowers than animals. Their name, *Lepidoptera*, is composed of two Greek words, *lepis*, a scale, and *pteron*, a wing, and means scaly wings, from the fact that the wings, in insects belonging to this order, are covered with minute scales.

As a rule, it is not difficult to recognize a member of this order, for while the species are very numerous, there are conspicuous general characteristics in shape, wing formation, etc., which are so strongly marked as to make them plainly recognizable even to the tyro. There are, however, some minor exceptions to this statement in the wingless forms, usually females, as the tussock-moth, the cankerworm, etc., and in the clear-winged moths, which so nearly resemble wasps that the beginner in entomology might be pardoned for mistaking them.

The order is again divided into two well-defined groups or suborders: the moths, or *Heterocera*, meaning variable horns, from the great variety of forms shown in their antennæ, and the butterflies, or *Rhopalocera*, or club-horns, in allusion to the form of their antennæ. The butterflies are all diurnal, or day-fliers, while the greater part of the moths are nocturnal, or night-fliers. Some moths fly in the daylight and many are on the wing during the twilight hours, between sundown and dark,

but by far the greater part of the members of this family are night-fliers.

Referring again to the antennæ, there is always a distinguishing feature here by which we can decide to which class either of these insects belongs, for while moths and butterflies, in some of their forms, so nearly approach each other that it is difficult to tell where to place them, the antennæ of the butterfly invariably end in a little club or knob, hence the name. The antennæ are always filiform, or thread-like, varying in thickness; but at the end there will be a knob, which is sometimes prominent, sometimes obscure, and varies in form in different species, but it is always present. With the moths, the antennæ always end in a point. In this group, there is a great variation in the form of the antennæ; they are feathered or branched, or filiform, sometimes very simple and sometimes very elaborate, but they invariably terminate in a point.

While, in their perfect state, this order is the most attractive of all the insect tribe, they are, in their larval stage, the most destructive of any. With the exception of the silkworm, whose products we have turned to our use, and a few minor species which are predatory, we may say that the whole order is destructive. They are vegetable feeders, and, in the form of caterpillars, often do enormous damage. Codling-moths, armyworms, cutworms, cankerworms, gypsy-moths, the brown-tail moths, and others of this kind, are too well known to our orchardists, while the housewife is troubled out of her life by the clothes-moth. They are a pest in everything, and do more damage than any of the other insect orders.

Another distinguishing feature is that, when at rest, the butterflies fold their wings perpendicularly over their backs, while the moths fold theirs horizontally. In the latter, the wings lie flat on the back, or are folded over it roof-like. There is one family of butterflies, commonly known as skippers, which seems to connect the two branches, and in these one pair of wings are folded, as in the butterflies, and the other lie flat, as in the moths.

The butterflies have well-marked peculiarities which separate them into natural groups, based on the character of the feet and the position of the antennæ. In the true butterflies, the head is very narrow, and the feelers are set close together on the top. The club on the antennæ is very prominent and well defined. In the skippers, which we have stated seem to form a connection between the two suborders, the head is much broader, the bodies stouter, and the antennæ, while ending in a club, are recurved and pointed, and they are widely separated and set close to the eyes.

It has been previously stated that all insects have six feet, from whence we have the name Hexapoda, applied to this section of the

insect world. In the case of some of the butterflies, it would seem at first glance that an exception was had to this rule. In many of them the fore legs and feet are aborted, and often not plainly visible. They are always present, however, even if indistinct. In these, the tibia or foot is represented by a brush, and these brush-footed butterflies are divided into two families: the Nymphalidæ, containing the moderate-sized and large species, and the Lycænidæ, small species, generally of a blue or coppery color, with the under side sometimes marked with hair-like streaks. These are commonly known as the blues, coppers, or hair-streaks. They are common in damp places and along watercourses.

There is a marked difference in the methods of transformation in the butterflies and moths. In the former, the pupa is known as a chrysalis; it is naked—not inclosed in a cocoon—and is always above ground, there being no subterranean forms. Usually the chrysalids are found attached to the under side of a limb, a stone, or some other convenient place, and usually pendent. They are, as a rule, obscure in color, although some are brilliantly marked with metallic colors, and some are ornamented with points like burnished gold.

The pupa of the moth is inclosed in a cocoon. This may be a silken web woven round it for its protection, the highest form of which we find in the cocoon of the silkworm, or it may be a mere case of hardened earth, silk-lined and buried.

The moths vary much more in their habits than do the butterflies, and are found in all places. Some are wood-borers, and pass their transformations in the trunks of the trees which have given them refuge; others are subterranean in their larval stage, and these construct cells of earth in making the change; others are plant feeders, and these may weave a cocoon in any available place. The butterfly is wholly aërial. Its larva is always found on the surface. It is not a borer or a burrower, with perhaps the exception of the genus *Megathymus*, one of the skippers, which in its larval stage is said to burrow in the underground stem of the yucca.

In the Lepidoptera the three principal divisions of the body are well defined. The head is small, rather broad in proportion to its length, and moves freely on the neck. The eyes are hemispherical and very prominent, of various colors in the different species, and sometimes showing a few hairs. Two ocelli are found in some of the moths, usually concealed beneath the hairy scales which cover the head, and are probably of no service as visual organs.

In their larval form, members of this order are popularly known as caterpillars, but the smooth species are often termed worms—which, by the way, like most popular names, is a misnomer—as cankerworms, apple-worms, cutworms, budworms, etc. They vary very much in size, form, and appearance, according to species. The body is usually

cylindrical, and is composed of twelve rings or segments, besides the head. The head is the most specialized part of the larva. It is usually covered by a horny plate, often divided down the middle into two equal parts. The jaws are broad and strong, serrated or toothed on the edges, with the under lip or labium well developed, while the maxillæ and palpi in most species are rudimentary. They differ very greatly from the mature insects; in fact, it may be said that they do not resemble them in any respect. In the larval form, caterpillars are vegetable feeders and are very destructive; their mouth parts are formed wholly for biting and chewing, while, in the perfect insect, these are entirely changed, and it lives by suction. The internal organs and all the external organs are changed in the process of transformation.

The first three segments behind the head are the thoracic segments, and these carry the jointed feet, which afterwards develop into the feet of the mature insect. These are known as the true legs. The remaining segments, usually nine in number, are known as the abdominal segments, and on these we find the false or prolegs, varying in number from two to five pairs. These are provided with a circle of minute hooks, in the place of feet, which enable the caterpillar to cling fast to the plants upon which it feeds. These prolegs disappear in the mature insect. Most caterpillars have sixteen legs, including the true and false legs. The loopers, or measuring-worms, however, have but ten, while the bag-worms have but six.

Suborder RHOPALOCERA. (Butterflies.)

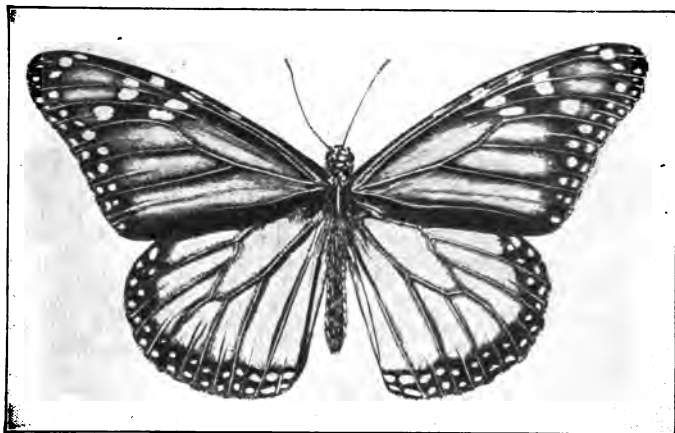
While the moths are the most important branch of the Lepidoptera, greatly exceeding in number of families and species the butterflies, and are of much greater economic importance from either a beneficial or an injurious standpoint, yet the former are the more widely known and admired largely owing to the nocturnal habits of the greater part of the moths, and also to the fact that a very large portion of them are obscure in coloring, while nearly all the butterflies are attractive.

Butterflies are separated into five families, representatives of all of which are found in California. These are:

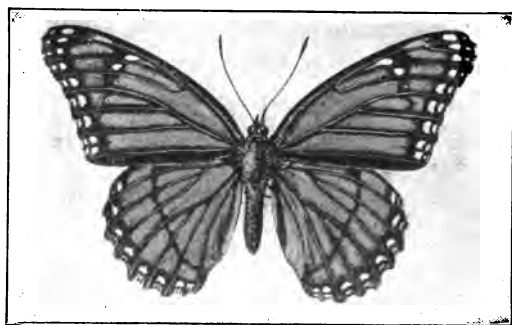
1. Nymphalidæ, the Brush-footed Butterflies.
2. Lemoniidæ, the Metal-marks.
3. Lycænidæ, the Blues, Coppers, and Hair-streaks.
4. Papilionidæ, the Swallow-tails, etc.
5. Hesperiidæ, the Skippers.

The family Nymphalidæ is distinguished from all other butterflies by the fact that in both sexes the first or prothoracic pair of legs is greatly dwarfed, useless for walking and carried folded up against the breast. On this account, members of this family are sometimes known as four-

footed butterflies. It is the largest of all the families, and has been divided into many subfamilies. It is generally composed of large or medium-sized insects, but there are some small species in it. Prominent in this family is the large Milkweed butterfly, or, as it is sometimes called, the Monarch (*Anosia plexippus*). This is a cosmopolitan



A



B

FIG. 59. A, *Anosia plexippus*, the "model"; B, *Basilarchia archippus*, the "mimic." Natural size.

insect, and is found nearly the world over. It is very common in California, and can often be seen on a summer day flying westward in large numbers. It is a large, red-brown insect, with the wing veins very broadly marked in black. The caterpillars, which are common on the milkweeds, are about an inch and a half in length, when fully grown, greenish in color, marked with black bars. It is pretty, even in its larval form, and the chrysalis is a most striking object, being marked with brilliant golden dots along the margin.

Family **Lemoniidae**. Butterflies belonging to this family are mostly confined to the new world, and largely to the tropical sections. Its distinguishing features are that the males have but four walking feet,

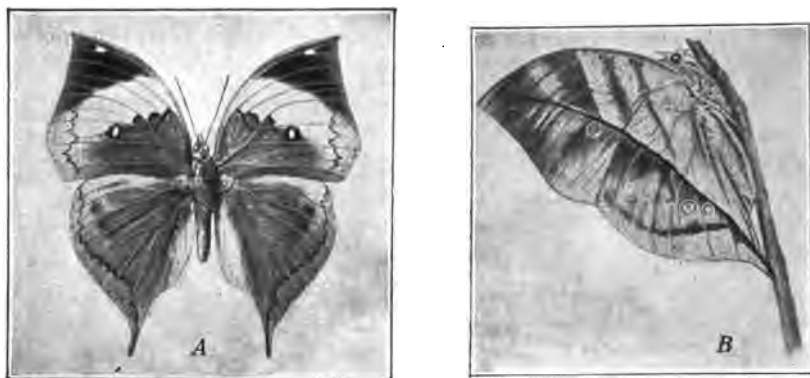


FIG. 60. *Kallima inachis*. A, upper surface; B, with wings closed, showing resemblance to a leaf.

while the females have six, and the antennæ are longer than in the first-named family. They are usually small insects, but are very brightly colored.

The family **Lycenidae** is a very large one of mostly small butterflies, and contains some of the most beautiful members of the order. Blue in various shades is a common color. In this family the males have four and the females six walking feet.

Family **Papilionidae** (Swallow-tails). In this family both sexes have six feet, and in it we find some of the largest and most striking forms in our State. One of the most common and showy of this family in



FIG. 61. Large white cabbage butterfly (*Pieris brassicae*).

our State is *Papilio tur-nus*, the large yellow swallow-tail, with a spread of wings over four inches. (See colored Plate I.) The ground color of its wings is bright yellow, crossed with broad dashes and streaks of black, with black border, inclosing crescent-shaped mark-

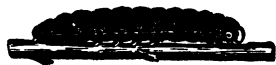
ings. Near the tips of the hinder wings are bright purple and yellow marks, which add to the beauty of this grand insect.

A second group of this family is the *Pierinæ*, which include the well-known cabbage-butterfly (*Pieris rapæ*). This is one of the worst pests

of all the butterfly tribe. It was imported from the Mediterranean region into Canada about the year 1868, and since that time has spread all over the American continent. It will be found in swarms over cabbage patches, alfalfa fields, and other sections, in which it finds its food plants, until the fields sometimes have the appearance of being in a snow storm. Its larva is the common green cabbage caterpillar. In

FIG. 62. Larva of *Pieris brassicæ*.FIG. 63. Small white cabbage butterfly (*Pieris rapæ*).

connection with the cabbage whites, we often find a bright yellow butterfly, known as the sulphur yellow. These belong to the genus *Colias* and are very common in alfalfa fields, as the larvæ feed upon clover. It is a green worm, very similar to the cabbage-worm, and so nearly the color of its food plant as to be difficult to find. In this State it feeds largely upon alfalfa, and while it does some damage to this crop, can not be regarded as a very serious pest.

FIG. 64. Larva of *Pieris rapæ*.

Family **Hesperiidæ** (Skippers). This family is of little economic importance to us. The genus *Megathymus* is said to have the habit, in its larval stage, of burrowing in the underground stems of the yucca, and, therefore, is somewhat of an anomaly among butterflies, as it is the only one which works beneath the surface. The family is interesting in the possession of certain characteristics which seem to connect the butterflies with the moths. Members of this family are small, with stout bodies, quick and powerful in flight, and have a peculiar jerky motion, from which their common name is derived. They have six well-defined feet in both sexes, and in their metamorphoses weave a light cocoon of a few silk threads, in this, as in many other respects, approximating the moths.

In North America alone there are over six hundred and fifty species of butterflies, but all belong to one or another of the families named.

Suborder **HETEROCERA**. (Moths.)

We now come to the second and more important division of the order Lepidoptera, the *Heterocera*, or moths. The species included under this division are far more numerous and of greater importance in every

way than are those classed as butterflies. Among the moths we find some of our most important insects from an economic standpoint; some few are also beneficial, as predaceous upon other pests; but by far the greater part of them are injurious to a greater or less degree, and some of them are among the most destructive, costly, and serious of all our insect enemies. The codling-moth, together with its destructive work, is well known to orchardists, and the bee-moth is a terror to the apiarist, methods to circumvent its destructive work racking the brains of our beemen. The Mediterranean flour-moth has, on many occasions, put large and costly flouring-mills out of business by so obstructing the machinery with its webs that it could not be operated. The clothes-moth and its destructive work are well known to every housekeeper, and so the list might be almost indefinitely extended.

As stated before, as most of these insects are nocturnal they are not so well known as the butterflies, which fly only in the light, but they are by far the more numerous, covering a wider range of families and species, and working their destructive operations in more diverse ways than the other members of the order.

The moths with which we are acquainted in the United States are divided into forty-three families, as follows:

- | | | |
|-------------------|---------------------|---------------------|
| 1. Sphingidæ. | 16. Bombycidæ. | 30. Ægeriidæ. |
| 2. Saturniidæ. | 17. Platypterygidæ. | 31. Pyralidæ. |
| 3. Ceratocampidæ. | 18. Geometridæ. | 32. Pterophoridæ. |
| 4. Syntomidæ. | 19. Epiplemidæ. | 33. Orneodidæ. |
| 5. Lithosiidæ. | 20. Nolidæ. | 34. Tortricidæ. |
| 6. Arctiidæ. | 21. Lacosomidæ. | 35. Yponomeutidæ. |
| 7. Agaristidæ. | 22. Psychidæ. | 36. Gelechiidæ. |
| 8. Noctuidæ. | 23. Cochliidiidæ. | 37. Xylorictidæ. |
| 9. Nycteolidæ. | 24. Megalopygidæ. | 38. Œcophoridæ. |
| 10. Pericopidæ. | 25. Dalceridæ. | 39. Blastobasidæ. |
| 11. Dioptidæ. | 26. Epipyropidæ. | 40. Elachistidæ. |
| 12. Notodontidæ. | 27. Zygaenidæ. | 41. Tineidæ. |
| 13. Thyatiridæ. | 28. Thyrididæ. | 42. Hepialidæ. |
| 14. Liparidæ. | 29. Cossidæ. | 43. Micropterygidæ. |
| 15. Lasiocampidæ. | | |

Family **Sphingidæ** (Hawk-moths). These moths fly at twilight, and are very noticeable because of their habit of hovering over flowers, from which they extract nectar by means of their extraordinary tongue, which is sometimes several times the length of the insect. Its larva is the large green worm often found on tomatoes, grapes, tobacco, etc. The caterpillars are peculiar in the possession of a sharp, curved horn on the last segment of the body, or in its place a hard eye-like spot. When at rest, some of them have the habit of elevating the

body and drawing back the head, giving them somewhat the resemblance of the Sphinx, from which they take their name. Some of the largest of the moths are found in this family, which includes many genera and species.



FIG. 65. White-lined Sphinx moth (*Deilephila lineata*). Natural size.

The family **Saturniidae** includes some of the largest and most beautiful of our moths, and the Emperor moth can be taken

as a type of this family. The larva forms a cocoon of silk and the insect is sometimes called the wild silkworm. Species of this family are not uncommon in our State, although, being a nocturnal insect, it is not so commonly met with as some of the day-fliers, and when found is sometimes considered as rare by the finder. One of the most striking members of the family which is found here is the *Samia cecropia*. The larva of this moth is a very large caterpillar, and is generally found on the wild shrubbery, although it sometimes attacks fruit trees. Its favorite fruit plant is the Cascara sagrada, or wild coffee, of our foothills.

The family **Ceratocampidae** comprises moths of large or medium size which do not produce cocoons, but undergo their metamorphosis underground. They are short-bodied and hairy, and usually beautifully colored in tints.

The family **Syntomidae** is of little interest to us, as its members are more objects of curiosity to the professional entomologist than to the producer, being in no sense of economic importance. They are small to



FIG. 66. Caterpillar of white-lined Sphinx moth. Slightly enlarged.

medium sized insects, diurnal in their habits, and frequent flowers. Many of them strongly resemble wasps in their form and markings, and are sometimes mistaken by the uninformed for those insects.

The family **Lithosiidæ** consists of small or medium sized insects, which feed principally upon lichens. They pupate in silken cocoons, in which the hairs of the larva are mixed. They are not, as a rule, destructive to cultivated plants, and so can be dismissed from further consideration here.

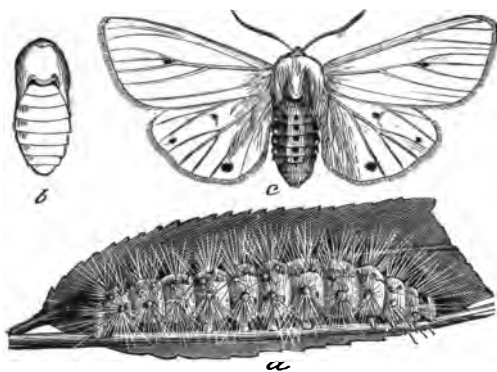


FIG. 67. Yellow bear (*Spilosoma virginica*). a, larva; b, pupa; c, moth.

The family **Arctiidæ** is a very large one, being represented by thirty-eight genera and over two thousand species, of which there are some hundred and twenty species in the United States. It includes the so-called woolly-bears and tiger-moths. They are stout-bodied moths with moderately broad wings and usually spotted or striped. Some of them are very highly colored and others are white. They are mostly nocturnal and are attracted to the light. Their larvæ are covered with long hairs, which grow in bunches, and they are very general feeders, being found on a wide range of vegetables. The Arctiidæ are represented in our State by the fall web-worm, although the family is a very numerous one with us.

The family **Agaristidæ** consists of day-flying moths, usually of moderate size, and it contains some of the most beautiful members of the insect world, although the most beautiful members of it are found in the tropics. In California the wood-nymphs are common, and are representative of this family here.

The family **Noctuidæ** includes a very large number of

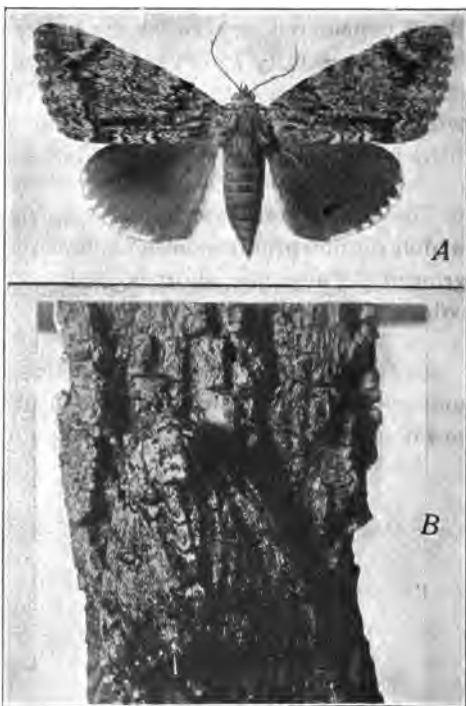


FIG. 68. *Catocala lacrymosa*. A, upper surface; B, with wings closed, and resting on bark. Reduced.

genera and species, there being hundreds of the former and thousands of the latter. The common name is owlet-moths, given them from their nocturnal habits, and their soft-downy appearance. In both respects they resemble owls. In their larval form they are injurious to vegetation, and are among the worst of our insect enemies in this order. The cutworms, which are so destructive to young plants, belong to this family. Many of the moths are dull colored, but, at the same time, the family gives us some of the most beautiful of insects. The catocalas, or underwings, also belong here. The members of this family have very distinct characteristics, by which they may be recognized, and the venation of the wings is especially very constant.

The family *Nycteolidæ* is a small one, resembling the *Noctuidæ* in many respects, and is represented in the United States by only two genera.

The family *Perleopidæ* somewhat resembles the wood-nymphs, but has a different wing venation. They are not common, and in our State are represented by *Gnophælia vermiculata*, a beautiful moth found in the foothill sections.

The family *Dioptidæ* is represented by only one species, and that a California one, the common live-oak moth (*Phryganidia californica*). This is the light-colored weak moth which appears in such great numbers on the live oaks and sometimes entirely defoliates them.

The family *Notodontidæ* includes a number of families of moths of moderate size, ranging up to two inches spread of wing. They strongly resemble the owlets, from which they differ principally in wing venation.

The *Thyatiridæ* are another family resembling the owlets, but which present sufficient difference to class it as a separate family.

The family *Liparidæ* is of interest to us, as it includes among its members the tussock-moth (*Hemerocampa vetusta*), which is very widely distributed and a very common pest in California. The females of this genus are wingless, or, at least, possess wings of a very rudimentary form. The female deposits her eggs on the cocoon from which she has emerged, and covers them with a frothy mass, after having performed which duty she dies. In spite of the common prejudice against caterpillars, it must be acknowledged that the caterpillar of the tussock-moth is a beautiful insect, with its bright yellow color, the coral red protuberances on the last dorsal segments, and the four creamy brush-like tufts on its back, with the two black plumes on the anterior, and one on the posterior section of the body. Altogether, as a caterpillar, it is remarkable for both form and coloring.

The gypsy-moth (of which we give a beautiful illustration in colored Plate XI), whose work of devastation in the Eastern and New Eng-

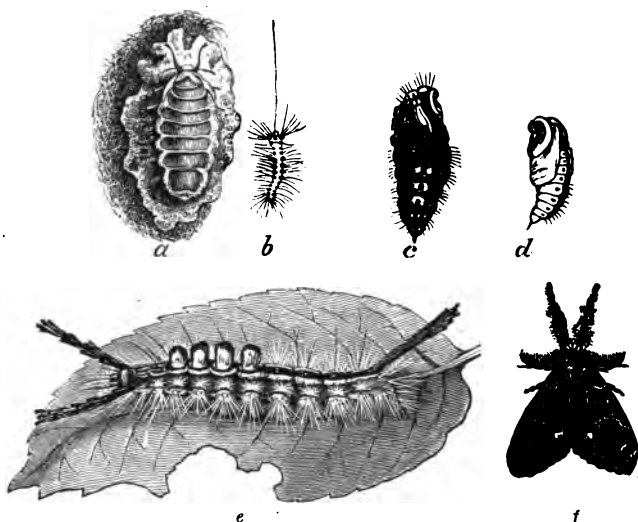


FIG. 69. Tussock-moth (*Hemerocampa vetusta*). a, female moth on cocoon; b, young caterpillar; c, female pupa; d, male pupa; e, larva on leaf; f, male moth.

land States has attracted the attention of the whole country, belongs, also, to this family.

The family *Laslocampidæ* is of interest to us principally from the fact that in it we find the tent-caterpillars. The most prominent members of this family are well known from their habit of forming a

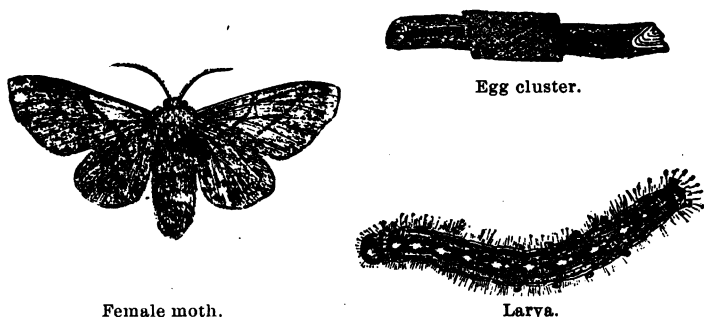


FIG. 70. Tent-caterpillar (*Clisiocampa sylvatica*).

covering or tent, in which they congregate, returning to it, as to a common home, after they have gorged themselves on the foliage of the trees which they infest. When they outgrow their tent, they form another. The orchard tent-caterpillar (*Clisiocampa americana*) is sometimes a very serious pest in our fruit orchards, especially apples,

sometimes entangling the whole tree with its webs. They live in communities, feed in droves, and are capable of doing great damage, unless checked.

The family **Bombycidae** includes the true silkworms. The true silkworm (*Bombyx mori*) appears to be an invention of man in the insect world. Its origin is unknown, none of its species existing in the wild state, and it has been so long under cultivation that it can not live unless cared for by man.

The family **Platypterygidae** has a few representatives among us, but they are of no economic importance.

The family **Geometridae** includes those caterpillars commonly known as loopers, inch-worms, measuring-worms, etc. They are all vegetable feeders and very destructive. In it we find the currant span-worm, the spring and fall cankerworms, and many others too well known to our fruit-growers. Over eight hundred species are known to exist in the United States and Canada. The caterpillars lack all save one pair, or in some cases two pairs, of the prolegs found in other



FIG. 71. Fall cankerworm (*Alsophila pomertaria*). a, male moth; b, female moth; c, joints of antennae of female, enlarged; d, segment of body of female, enlarged; e, larva.

caterpillars, and in moving are compelled to make the peculiar motions which give them their popular names. They first extend the body its full length, then bring the posterior end close up to the forelegs, looping the body in the middle, then stretch out the fore part of the body again, and continue these motions until they reach their desired destination. The moths have slender bodies, small heads, and very broad, thin wings. In many species the females are wingless, as in the cankerworms.

The family **Epiplemidæ** is a small one, closely related to the Geometers, but of little importance to us.

The family **Nolidæ** is another small one of rather small moths, which are of little interest except to the systematic entomologist.

The family **Lacosomidæ** is a small one, and consists of moths peculiar to the western hemisphere. It is thus described by Holland: "While the perfect insects show structural resemblances to the Platypterygidae, the caterpillars, which have the habit of constructing for themselves portable cases out of leaves, which they drag about with

them, resemble in some respects the Psychidæ. The young larva of *Cicinnus melsheimeri*, immediately after hatching, draws together two small leaves with strands of silk, and makes between them its hiding-place. Afterwards, when more mature, it detaches two pieces of leaves, and makes out of them a case which it carries about with it, and which it can desert at will. When at rest it ties the case to a station selected with a few strands of silk, which it bites off when it desires again to start on a journey among the branches. The larva of *Lacosoma* makes a case by doubling a leaf at the midrib, cutting it off at the petiole, and taking it with it as a portable house. There are only two genera of this family in our fauna. It is more abundantly represented in the tropics of South America."

The family **Psychidæ** is of more interest to us, however, as in it we find the bag-worms, or basket-worms, so called from the curious habit the larvæ have of making for themselves a case, or basket, or shelter, composed of pieces of leaves, grass, or fragments of wood or other vegetable substances. These fragments are carefully joined together and lined with silk, spun by the insect. In this case the caterpillar lives securely, and carries it along wherever it goes, much as the snail does its shell. It does not do much damage in our State, as it confines itself to conifers and is not very common. When the bag-worm has attained its full growth, it attaches the bag to a twig and changes to a pupa within it. The male emerges a full-winged insect, but the female is wingless and never leaves the sack, laying the eggs for a new generation within the house she has inhabited during her life.

The family **Cochlididæ** consists of slug-like caterpillars, and contains a number of interesting, modest green or brown moths. They are usually of small size and very densely clothed with scales or hair. The larvæ resemble slugs in their general form, being usually oblong in shape and flattened. They have no visible legs and move like slugs. Some of these larvæ have stinging powers, and can inflict a sharp, burning sting when carelessly handled.

The family **Megalopygidæ**, or flannel moths, is a small family of whitish moths, having their wings densely clothed with long, curly hairs resembling bits of flannel. Their larvæ have ten pairs of legs—three pairs of true legs and seven pairs of prolegs—a larger number than in any other family of lepidopterous larvæ. The cocoons have a trap door, through which the moth escapes after it has passed its metamorphosis.

The family **Daleeridæ** is a small one, of no interest to the fruit-grower.

The family **Epipyropidæ** is of interest to us from the fact that it is a family of parasitic moths. Among all the vegetable pests of this order,

it is so pleasant to find one that does something toward redeeming its reputation by being of some service in checking pests.

Of the family *Zygænidæ* but few species occur in the United States, and none are destructive to fruit trees.

The family *Chalcosidæ* is represented by but a single insect, an obscure moth known as *Gingla laterculæ*, found in Arizona.

The family *Thyrididæ* is a small one, and consists of small moths characterized by the presence of small white or yellowish translucent spots on the wings.

The family *Cossidæ* is of more interest to us, for in this we find some of the most destructive of the moth family. To this belong the goat-moths or carpenter-moths, as they are popularly known. In their larval stages they live in the roots and trunks of trees and sometimes do great damage to the tree which they infest. In some cases, in the East, orchard trees have been killed in great numbers by the ravages of these moths. They are said to remain in their larval stage for three years, before they have attained their growth. They pass their transformation in the burrows which they have eaten out in the wood, and when ready for the change the larva forces itself partly out from the burrow. When the moth has emerged, the empty pupa skin can be seen protruding from the burrow. The species most common in California is *Prionoxystus robiiæ*. It is a large gray moth, much resembling the sphinx-moth in general appearance, and flies by night. They are destructive to elms, locusts, and forest trees, but have not as yet been reported as doing damage to fruit trees in our State.

In the family *Ægeridæ* we have the clear-winged moths—a family utterly unlike any other branch of the Lepidoptera, and many of the members more resembling wasps than moths. They are of small size, with slender bodies, and fly only by day and frequently in the brightest light. They are all borers, and among them are some of our most destructive pests, the Western peach-root borer (*Sanninoidea opallescens*), the Eastern peach-root borer (*S. exitiosa*), the currant borer (*Alcathoe caudatum*), and many others, being representative of the family. Many of the matured insects are very beautiful, and most of them are remarkable on account of their protective mimicry, resembling, as they do, insects of different orders, especially bees, wasps, and flies. This strong resemblance to stinging insects often protects members of this family from danger to which their day-flying habits would otherwise expose them. Yet, in spite of their threats of danger, which are carried out in their acts as well as in their coloring, they are harmless, and it is all a mere bluff on their part to frighten their enemies.

The worst representative of this family which we have in this State is the peach-root borer (*Sanninoidea opalescens*). The following description of the different stages of this insect will aid those who are troubled with this pest in detecting it:

Egg.—The egg is very minute, not exceeding $\frac{1}{4}$ mm. in length, oval, light brown in color, and, when seen through a lens, ornamented with hexagonal sculpturing. The eggs are deposited on the bark of the tree, at or near the surface of the ground; rarely they are laid high up on the trunk or even in the crotches of the trees. This last phase is generally found in the grafted trees, where gummy exudations have occurred and where grafting has somewhat soured the sap.

Larva.—The young larvæ, on hatching, are very active and immediately burrow into the tree, generally entering the cracks in the bark

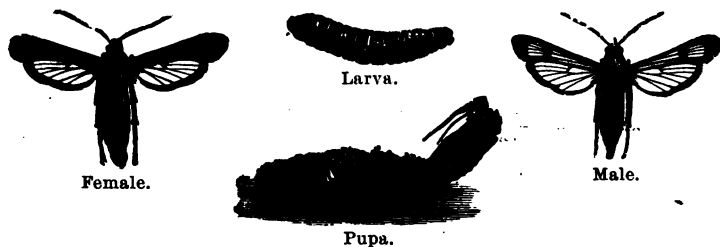


FIG. 72. Peach-root borer (*Sanninoidea opalescens*).

at or below the surface of the ground. Here they remain constantly feeding on the bark, at first near the surface, surrounding themselves with gum, or coagulated sap, and gradually enter the sapwood, enlarging their burrows as they increase in size. The full-grown larva is pale yellow, about one inch long, tapering with a brown head. After attaining its growth, the borer ascends in the burrow to or above the surface of the ground, as the case may be, and begins to spin a cocoon.

Cocoon.—This is made up of a silken web mixed with castings and earth glued together, and is of a brown color, from $1\frac{1}{4}$ to $1\frac{1}{2}$ inches long.

Pupa.—The pupa within the cocoon is shiny, light brown, with numerous spines on the abdomen. When about to emerge the pupa is pushed out of the cocoon, and soon the adult moth emerges.

Moth.—To the novice this insect would appear more like a blue wasp than a moth. The female differs so much from the male that they might be taken for two distinct species. The female has bluish-black, opaque front wings, while the hind wings are transparent, like those of a wasp; the margin of both wings has a bluish-black fringe; antennæ, head, thorax, and abdomen are very dark steel blue, almost black; wing expanse, $1\frac{1}{2}$ inches. The male has fore wings nearly transparent, with upper margin and tips black; hind wings are transparent, like those of female; the body is bluish black; the abdomen is much narrower than that of female and more elongated; legs are black, with yellow tufts on femur and tibia; wing expanse, $1\frac{1}{4}$ inches.

The family **Pyraltidæ** includes moths generally of small size, some so small in fact as to be classed as micro-lepidoptera. It has been divided into a great number of subfamilies, genera, and species, so that it would be impossible in a limited space even to mention them all. It contains, however, a number of species injurious to plants, among them the leaf-crumplers, leaf-rollers, case-bearers, and several fruit-worms.

In the family **Pyraltidæ**, and subfamily **Galleriinaæ**, we find that pest of the bee men, the bee-moth (*Galleria mellonella*). This pest is described by Prof. C. V. Riley as follows: "During the daytime these moths remain quietly ensconced in some angle of the hive, but as night approaches they become active, and the female uses her best endeavors to get into the hive, her object being to deposit her eggs in as favorable a place as possible. Wire gauze contrivances are of no avail to keep her out, as she frequently commences flying before all the bees have ceased their work. But even if she were entirely prevented from entering the hive, she could yet deposit her eggs on the outside, or, by means of her extensive ovipositor, thrust them in between the slightest joint or crack, and the young worms hatching from them would readily make their way into the hive. The moment the worm is hatched, it commences spinning a silken tube for its protection, and this tube is enlarged as it increases in size. The worm cuts its channels right through the comb, feeding on the wax, and destroying the young bees on its way. When full-grown, it creeps into a corner of the hive, or under some ledge at the bottom, and forms a tough, white cocoon of silk mingled with its own black excrement. In due time the moth emerges from this cocoon. A worm-infested hive may generally be known by the discouraged aspect which the bees present, and by the bottom board being covered with pieces of bee-bread mixed with the black, gunpowder-like excrement of the worm. * * * If a hive is very badly infested with the worms, it is better to drive out the bees and secure what honey and wax there may be left than to preserve it as a moth breeder to infest the apiary. If put into a new hive, the bees may do something; and if they do not, there is no loss, as they would have perished, finally, from the ravages of the worm."

The family **Pterophoridaæ** includes those graceful, elegant little moths commonly known as plume-moths, from the fact that their wings are divided in such a manner as to suggest feathers. Sixty species are known in the United States. They are vegetable feeders, but do little damage to fruit.

The family **Tortricidæ** is so named from its habit of rolling up the leaves of plants upon which the insects feed, and on this account they have received the common name of "leaf-rollers." It must be remembered, however, that not all leaf-rollers belong to this family, nor are

all of its members leaf-rollers. The family includes a number of sub-families, genera, and species. Many of them live in plants or burrow



FIG. 73. Codling-moth (*Carpocapsa pomonella*), showing variations. All natural size.

into fruits or the stems of plants, and in this family we find that most destructive of all fruit pests, the codling-moth (*Carpocapsa pomonella*). This one pest causes a loss to the fruit-growers of America running into tens of millions of dollars annually. While the other members of this family

are hurtful to plants, none of them, nor all together, have attained the unenviable prominence of the codling-moth.

The family *Yponomeutidæ* is of moderate size, containing about sixty species in the United States. It is of little economic value.

The family *Gelechiidæ* consists of small moths, many if not most of them being injurious to vegetation. One of these, an introduced species, by the way, is the potato-moth, which is becoming a very severe pest in this State. In this family, too, is found the destructive peach-twig borer (*Anarsia lineatella*). This pest, like all our worst insects, was probably introduced into California from Japan, of which country it seems to be a native.

The families *Xyloriectidæ*, *Æcophoridæ*, *Blastobasidæ* and *Elachistidæ* are generally small families of small insects. Their different peculiarities have caused them to be assigned to separate families, but, except to the systematic entomologist, they are of little interest.

In the family *Tineidæ*, however, we have some members which are of direct interest to us. This is a very large family, generally of small moths, although some of them attain moderate size. These insects have narrow wings bordered with a fringe, and some of them, although exceedingly small, are very beautiful. Some of the members of this family are so minute that they attain their full growth and undergo their metamorphosis within the tissue of the leaves in which they live. Some of them, when they appear in great numbers, are very destructive. When it is considered that the leaves of trees are often no thicker than a sheet of paper, and that they consist of an upper and a lower surface,

or skin, and that on the fleshy part of the leaves, between these two layers, these insects feed and live and pass through all their changes, it will be understood how minute they, or some of them, are. It is in this family, too, that we find that greatest of all pests to the careful housewife, the clothes-moth (*Tineola bisselliella*). This is not the only culprit, however, for while to the disgusted housewife, who finds her woollens eaten full of holes, there is but one clothes-moth, the entomologist recognizes several species, all guilty of like destruction. Among these are the case-bearing clothes-moth (*T. pellionella*), the tube-building clothes-moth (*T. tapetzella*), and the naked clothes-moth (*T. bisselliella*), mentioned above.



FIG. 74. Cigar case-bearer (*Coleophora fletcherelli*).

The family **Hepialidæ** is a small one, composed of large or moderate sized moths. Its members are not sufficiently numerous to be of importance economically.

The **Micropterygidæ**. The last family of this branch of the order Lepidoptera is one of little importance to our readers. This family is remarkable only for the reason that it reveals certain anatomical features which are thought to point out an early connection between this and other orders.

Order **DIPTERA**.

(Two-winged Flies.)

Like that of the other orders of insects, the name of this order is composed of two Greek words, *dis*, two, and *pteron*, wing. As before stated, the wing peculiarities have been taken by entomologists to divide the orders of insects, and in this order most of the members have but two wings, while in all others, as a rule, there are four wings present. But even to this rule there are exceptions, as we have shown, for in most of the orders some of the members are wingless, while in some, as in the male of scale insects, there are two-winged insects. But the rule works in the Diptera to this extent, that most of its members have two wings and no more. There is in them what appears to be the rudiments of another pair, in a pair of little knobbed hooks, known as halteres, which occupy the place of hinder wings in the members of other orders. These halteres are present even in those few species in which the fore wings are entirely absent.

As with the word "bug," so with the word "fly"; it is wrongly used. To the average person, either of these terms may mean almost any kind of an insect, the latter, of course, being applied to insects with wings

which are not butterflies or moths. The name "fly," however, is only properly applied to members of the order Diptera.

Considering the number of individuals and the number of species, flies very greatly exceed any other order. They are common everywhere, in the houses, fields, swamps, and plains. Their members swarm in every place ever penetrated by man. Within this order are some of the most serious pests with which we are troubled, and they attack alike our animal and vegetable products, and man himself suffers more from them than from any other of the orders. We can escape in some manner our insect enemies in the other orders, but not always the Dipterons.

In this order we have the mosquito family, some members of which spread disease and death in the germs of yellow fever and malaria. It may be safely asserted that this family alone is the source of greater suffering, hardship, and even death to mankind than any other one cause. This order, too, furnishes the dreaded fruit-flies, one of the most destructive pests with which the fruit-grower has to cope, and which fortunately has not yet obtained a foothold in California. The disreputable botfly; the sheep-tick, a wingless form; the Hessian-fly, which causes a loss to the farmers of the United States of \$100,000,000 annually; the ox warble fly, which causes a loss as high as \$40,000,000 on hides, and others too numerous to mention, but most injurious to a greater or less extent, all belong to this order of two-winged flies. At the same time, there are many of its members which are friendly to man and which give us some of our most valuable beneficial insects. Among these are the Tachnid flies, one of which is the principal check on the locusts, and without whose work California would suffer severely every season from the locust pest. The Syrphus flies are another of our friendly families which feed upon the aphids and serve largely to keep them down.

As indicating the vast numbers of this order, it may be stated that there are already over 40,000 described species, and it is estimated that this number would be increased to 350,000 if all the species were known.

All the members of this order are suctorial insects, and their mouth parts are formed to this end. The methods of different species in procuring their food, however, differ widely. Some simply absorb fluids, or reduce their food to a fluid state, in order to absorb it, as with the house-fly; others are provided with a piercing beak, with which they are enabled to drill a hole into their victim and suck his blood, as with the mosquito. Some absorb the juices of vegetables, others of animals, and others again have no choice but to take whatever comes handiest.

The larvæ of flies are known as maggots. They are usually footless grubs, and pass through a perfect transformation. In some cases the eggs hatch within the body of the female, and the young maggots are

produced alive, and, in other cases even, the female gives birth to the young in the pupa form. As a rule, however, there are the usual well-defined periods of the insect life. With many of the flies, as in the case of meat-flies, the eggs hatch very soon after deposition, and the insect passes through all its changes in a very short time. In this we see a wise provision of nature, which arranges that the fly shall pass through its young stage and reach perfection while its food is available. If it were to remain long in its larval stage, its food supply would putrefy, and dry up before the insect matured, and the young fly would die of starvation.

Flies are adapted to various conditions, and breed under all circumstances. Some are aquatic, as the mosquitoes; some subterranean, as the crane-flies. Many breed in dirt and filth, and some swarm in cesspools, as the rat-tailed larvæ—the young of a *Syrphus* fly—and we have seen masses of maggots crawling in the crude oil running from the wells, and apparently well satisfied with conditions which would have knocked out any other form of insect life.

One of the most terrible of the dipterous pests is the so-called screw-worm (*Comptosmyia macellaria*). This is a common species throughout a large portion of our country, and ordinarily feeds upon dead or decaying vegetable matter. Under some circumstances, however, it attacks living animals, and in the Southern and Southwestern states occasionally becomes a terrible pest. On such occasions it lays its eggs on man or animals wherever there is the slightest trace of a wound, bruise, or offensive discharge of any kind. The larvæ bore directly into the living flesh, causing intense pain as well as suppurating sores. Living larvæ are produced, as well as eggs almost ready to hatch, and in any opening from which there is a discharge of any kind eggs may be deposited. Sleeping humans with an offensive breath, or with a fetid discharge from the nostrils or mouth, have had eggs laid at these points, and larvæ have made their way into the head in some cases, causing the death of the individual. Eggs have also been laid in the ears of uncleanly people, and the channels and passages of these organs have been penetrated into the head and destroyed. Animals are troubled in the same way, and where the insects are abundant their attacks often become fatal. The following, which appeared in a San Bernardino paper several years ago, gives a very vivid account of the work of this dreaded insect: "George Madden, a Western Union Telegraph lineman, was brought to the county hospital from the desert afflicted with a most loathsome complaint, actually being eaten up alive by thousands of minute worms which have hatched from the eggs laid in his nostrils while he was asleep. A description of his condition is too revolting to be printable. Madden states that three weeks ago he was employed by the telegraph company at Los Angeles and was

sent to the Arizona desert. At night he was considerably pestered by gnats, but had no idea of the terrible danger to which he had been exposed until a week later, when he was seized with dizziness. He was taken to Needles, where it was discovered that the gnats had deposited eggs in his nostrils and that they were hatching. The poor fellow was brought here, where everything possible is being done to allay his sufferings, but no hope is entertained for his recovery. This is the second case of the kind treated here."

The Diptera are divided into two suborders, the Orthorrhapha, in which the insects make their escape from the pupa case either through a T-shaped slit near the head, or in fewer species through a crosswise slit between the seventh and eighth abdominal segments. The second suborder is the Cyclorrhapha, in which the insect, after passing its metamorphosis, escapes from the pupa case through an opening made at the head part of it. These two suborders are divided into families, according to Comstock's classification, which we have adopted, as follows:

Suborder ORTHORRHAPHA.

1. Psychodidæ, the Moth-like flies.
2. Tipulidæ, the Crane-flies.
3. Blepharoceridæ, the Net-winged Midges.
4. Dixidæ, the Dixa-midges.
5. Culicidæ, the Mosquitoes.
6. Chironomidæ, the Midges.
7. Mycetophilidæ, the Fungus-gnats.
8. Cecidomyiidæ, the Gall-gnats.
9. Rhyphidæ, the False Crane-flies.
10. Orphnephilidæ, the Solitary-midge.
11. Bibionidæ, the March-flies.
12. Simuliidæ, the Black-flies.
13. Tabanidæ, the Horse-flies.
14. Stratiomyiidæ, the Soldier-flies.
15. Leptidæ, the Snipe-flies (in part).
16. Acroceridæ, the Small-headed flies.
17. Nemistrinidæ, the Tangle-veined flies.
18. Asilidæ, the Robber-flies.
19. Midaidæ, the Midas-flies.
20. Apioceridæ, the Apiocerids.
21. Bombylidæ, the Bee-flies.
22. Therevidæ, the Stiletto-flies.
23. Scenopinidæ, the Window-flies.
24. Empididæ, the Dance-flies.
25. Dolichopodidæ, the Long-legged flies.
26. Lonchopteridæ, the Spear-winged flies.

Few of the families of this suborder are of interest to us from an economic viewpoint, as most of those mentioned have no direct bearing upon our welfare; they may, therefore, be dismissed with a bare mention. Some, however, are of more importance, as among them we find some of our most beneficial insects, our friends, as well as some that are very destructive, or, at least, very injurious to us.

The family **Psychodidæ** consists of small flies very much resembling moths in appearance, and are often found on the under side of leaves.

The family **Tipulidæ** includes the crane-flies, sometimes popularly called daddy-long-legs. The larvæ of these flies live in the ground and are very tough and wiry, resembling wireworms in this respect. They live on grass and grain roots and may become very destructive. Sometimes they are so numerous as to kill out lawns in which they have become established. There are a large number of species, ranging in size from a gigantic insect, an inch and a half in length, with a spread of leg several inches in diameter, to some not larger than mosquitoes, which they greatly resemble in general structure. This family is representative, so far as the structure is concerned, of a large group, the *Midges*, which resemble them. In these the bodies are long and tapering, the legs generally very long and usually widely spread, so that the insect has the appearance of walking on stilts.

The family **Blepharoceridæ**, the net-winged midges, includes several families of aquatic insects, somewhat resembling mosquitoes in form, but different from them in wing venation. They breed in swiftly running water, and in some species there are two forms of females, one of which is blood-sucking, while the other lives by sipping nectar.

The family **Dixidæ** is another family of midges also resembling mosquitoes, and differing from the former family in wing venation.

The family **Culicidæ** is one altogether too well known, as it is in this that we find the whole abominable race of mosquitoes. This is not a very large family, although it is perhaps one of the worst enemies with which the animal world, including man himself, has to contend. Members of this family are found the world over. In some sections of the tropics they are so bad as to render the places infested by them uninhabitable, and miners

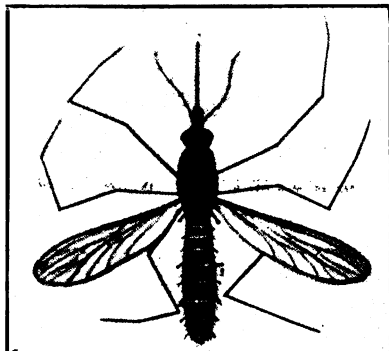


FIG. 75. Adult female of *Culcx pipiens*, enlarged. (Miss. Agr. Exp. Station.)

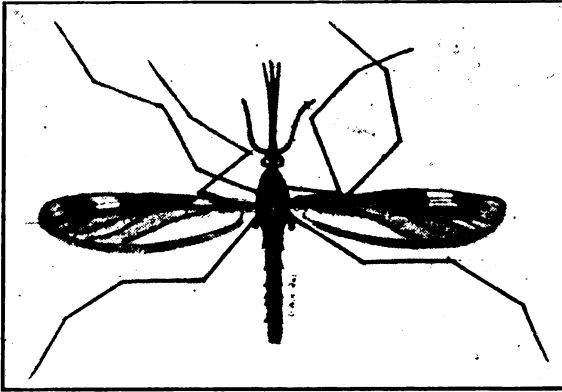


FIG. 76. Female of *Anopheles punctipennis*, enlarged. (Miss. Agr. Exp. Station.)

in far northern Alaska report them as the severest plague of that section. Explorers have not yet penetrated sufficiently far to the north or south to escape the mosquito. Every one dreads this pest. Their droning sound in the still hours of the night always brings with it a feeling of irritation and dread, and the poisonous

wounds inflicted by them are well known to everybody. It has now been definitely proven that the bite of the common mosquito, *Culex irritans*, with all its pain and irritation, is the lesser evil inflicted by the members of this family, for there is now no doubt that they are active agents in the spread of malaria and yellow fever, and perhaps of other malignant contagious diseases. To the non-entomologist a mosquito is a mosquito, but to the entomologist there are numerous species included under this title, all of varying degrees of badness, ranging from bad to worse and worst, the plagued *pipens*, which annoy us so, not being among the worst. The malaria-spreading mosquito is known as *Anopheles maculipennis*, while that to which we owe the dissemination of yellow fever goes by the name of *Stegomyia fasciata*. It would seem that the

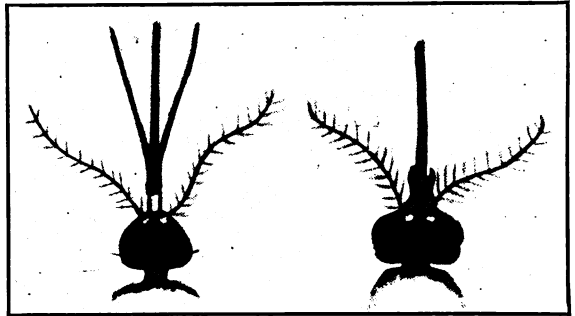


FIG. 77. At left, head of male *Culex*; at right, head of female *Culex*, enlarged. (Miss. Agr. Exp. Station.)

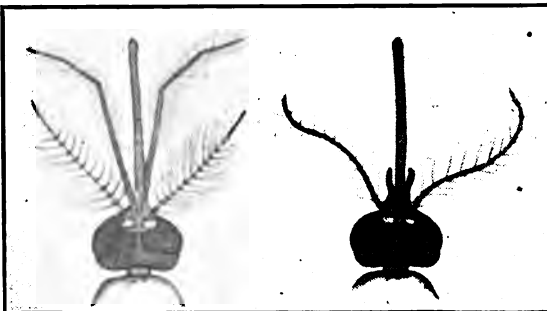


FIG. 78. At left, head of *Anopheles*, showing appendages; at right, head of *Culex*, showing appendages Enlarged. (Miss. Agr. Exp. Station.)

under this title, all of varying degrees of badness, ranging from bad to worse and worst, the plagued *pipens*, which annoy us so, not being among the worst. The malaria-spreading mosquito is known as *Anopheles maculipennis*, while that to which we owe the dissemination of yellow fever goes by the name of *Stegomyia fasciata*. It would seem that the

blood-sucking propensity of the mosquito family is an acquired taste, for while all that can, absorb our blood with that of other warm-blooded animals, they breed in countless billions in swamps and marshes, far from any warm-blooded animals, and there they live and die without tasting blood.

The mosquito breeds in water, and the so-called wigglers found in stagnant pools are the young form or larvæ. While aquatic in their mode of life, these larvæ are air-breathing, and have to come to the surface for a supply of air. For this reason they frequently come to the top, stick out their breathing apparatus, which is a sort of tail-like tuft, and after absorbing the supply of air, disappear in the depths of their breeding-pool again. It is for the reason that the larvæ are compelled to come to the surface to breathe that pouring coal oil over stagnant pools will keep them down and is the most effective remedy for this evil.

The family **Chironomidæ** are the true midges, small mosquito-like insects. They differ from the former family in their wing markings and habits, not being addicted to blood sucking. Sometimes they are so numerous as to be annoying, but otherwise they are neither good nor bad.

The family **Mycetophilidæ** consists of small to medium insects, generally resembling the mosquito in structure. The larvæ live upon fungi and decaying vegetable matter.

The family **Cecidomyidæ**, the gall-gnats, are small insects, including the smallest of this order. Their common name indicates their habits. Many of them are very serious pests to the farmer, for in this family are many which attack crops, as the clover-leaf midge and the wheat midge, both of which do great damage to crops, and here we have that worst of all grain pests, the Hessian-fly. It is impossible to accurately estimate the amount of damage actually inflicted upon our farmers annually by this pest, but it runs into the hundreds of millions. Fortunately the wheat-growers of California have not been troubled much by this insect, due, probably, to the habit of burning over old stubble in the fields, by which means the eggs are destroyed.

The **Rhyphidæ**, the false crane-flies; the **Orphnephilidæ**, the solitary-midges; the **Bibionidæ**, the March-flies; and the **Simuliidæ**, the black-flies, are all families of little importance except to the entomologist.

The family **Tabanidæ** includes the horse-flies. These are well known and are one of the worst pests of our domestic animals during the summer season, when they sometimes attack horses in swarms and cause them much trouble. These insects have such sharp mandibles

that they can pierce the skin as soon as they alight, and man himself often suffers from their attacks. In their larval, as well as in their mature, form, these insects are carnivorous.

The family **Stratiomyidæ**, or soldier-flies, is so named from the bright-colored stripes borne by some members. These flies are common in the vicinity of swamps, and are both carnivorous and vegetarian.

The family **Leptidæ** embraces the snipe-flies, so called from the fancied resemblance to those birds, due to a lengthened abdomen. The members of this family are predaceous, and frequent low shrubbery and grass. The larvæ live in the earth, decaying wood, and sometimes in water, and in this form they are always predaceous.

The family **Acroceridæ** are the small-headed flies, peculiar-looking insects, in which the head is disproportionately small in comparison with their bodies.

The family **Nemistrinidæ** are medium-sized insects, some of them resembling horse-flies.

The family **Asilidæ** includes the robber-flies, of which there are so many species, and all are predaceous, preying upon other insects. They live largely upon moths, and in their larval form prey upon the larvæ of beetles. They are not at all discriminating in their choice of food, however, and attack many insects. They are mostly large flies, some species being an inch or more in length. Usually they are long, with a sharp, tapering abdomen, although some species are short and stout and somewhat resemble a bumblebee in form. From their predaceous habits and their voracious appetites, they may be classed as beneficial insects.

The **Midaidæ**, the midas-flies, which resemble the robber-flies somewhat in appearance; the **Bombylidæ**, the bee-flies, in which family there are many which strongly resemble bees in color and markings; the **Therevidæ**, or stiletto-flies, are all families of little importance except to the professional entomologist.

The **Scenopinidæ**, or window-flies, are so called from their habit of congregating in the windows. They are small insects with a long, slender body, much sharper than the common house-fly, and in the larval form are sometimes found under carpets and in decaying wood.

The last family in this suborder is the **Lonchopteridæ**, or spear-winged flies, and one of little interest to us.

Suborder **CYCLORRHAPHA.**

The second suborder into which the Diptera are divided is the *Cyclorhapha*, which includes all those flies which make their escape from the pupa case, or larval skin, by a round opening formed in the top by the imago pushing out its head, the first suborder which we have been considering escaping through a slit made in the back.

1. Syrphidæ, the Syrphus-flies.
2. Pipunculidæ, the Big-eyed flies.
3. Platypezidæ, the Flat-footed flies.
4. Phoridæ, the Humpbacked flies.
5. Conopidæ, the Thick-head flies.
6. Œstridæ, the Botflies.
7. Muscidæ, the Muscids.
8. Hippoboscidæ, the Louse-flies.
9. Nycteribiidæ, the Bat-ticks.
10. Braulidæ, the Bee-louse.

The family first to be considered here is the **Syrphidæ**, in which we find several beneficial species. This is a very large family and includes over 700 species so far named and described. They are moderate-sized insects and are great mimics, many of them strongly resembling bees, wasps, and other insects. In fact, the *Eristalis tenax*, or drone-fly, so strongly resembles the honey-bee that it is frequently mistaken for it, the principal difference being in the fact that it is a dipterous insect, while the bee has four wings. Another difference is that this insect has no sting, although its strong resemblance to the honey-bee admonishes the ignorant to avoid it. The larva of this fly lives in cesspools and decomposing filth of any kind. It is provided with a long breathing tube, which is a continuation of the abdomen, and it is commonly known from this appendage as the "Rat-tailed larva."

A common member of this family is a black and yellow banded insect, much resembling a yellowjacket, which may be seen hovering motionless in the air over flowers on a summer day, making a sudden dart occasionally in one or another direction. The larva of this is predaceous on aphids, and is one of the many beneficial insects to which we owe so much.

The larvæ of the different species of Syrphus-flies have various feeding habits; some, as stated above, are predaceous on aphids; some feed on decaying animal and vegetable matter; some are found in the nests of ants, and others in the nests of bumblebees and wasps.

The **Pipunculidæ**, or big-eyed flies, are remarkable mainly for the disproportionate size of their eyes, which seem to swell the head beyond the size of the body. They frequent plants and are parasitic on bugs.

The **Phoridæ**, or humpbacked flies, is a family of small insects, the larvæ of which are parasitic.

The **Conopidæ** is a family of large-headed flies, any of which in their mature form resemble wasps in general appearance, having the abdomen elongated and connected with the thorax by a slender pedicel. They are common among flowers, and their larvæ are parasitic on bumblebees and wasps.

The family **Æstridæ** consists of the botflies. The members of this family are medium to large in size, of heavy build, resembling bees in general structure, and the family contains some of the worst pests which our four-footed animals have to struggle against. In this family is found the botfly of the horse, the warble of the ox, the sheep gadfly, and their kindred, which, in their larval stage, live upon the intestines or muscles of quadrupeds.

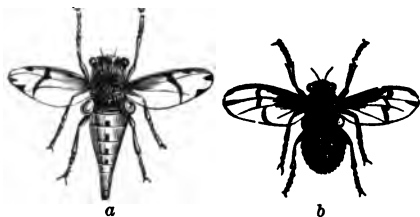


FIG. 79. Horse botfly (*Æstrus equi*). a, female; b, male. Both enlarged.

The reproduction of these insects is one of the freaks of nature, and is accomplished in the most round-about manner. The female of the horse botfly lays her eggs on the legs or other handy portions of the

horse, and so well does the animal know his enemy that horses will run in terror from them. The eggs are small yellowish bodies, furnished with hooks, by which they are attached to the hairs of the horse, usually the lower portion of the legs. It is wonderful, too, with what rapidity a fly will attach her eggs to the selected spot. We have watched them in action, and seen them dart at the spot and away again, not even resting, but in the short contact an egg was securely placed. The eggs are taken into the mouth of the horse, which licks itself, and the moisture and warmth cause them to hatch at once. The irritation occasioned by them causes the animal to swallow them and then they attach themselves to the coating of the stomach, where they remain until they have attained their larval growth, which requires eight or ten months. They are then passed, and fall to the ground, going through their pupa stage underground.

The ox warble is also taken into the stomach of the animal, but works its way between the muscles until it reaches the back, where, just beneath the skin, it grows rapidly until it has reached its full larval growth, when it enlarges an air hole, which it had already made in the skin, and passes out, dropping to the ground and going through its transformation underground.

The family *Muscidae* is the largest of the whole order, including about one third of all the species of *Diptera* known. The common house-fly belongs to this family. Comstock separates this family into two divisions, the *Calyptrate Muscidae* and the *Acalyptate Muscidae*, and under each of these divisions there are several subfamilies.

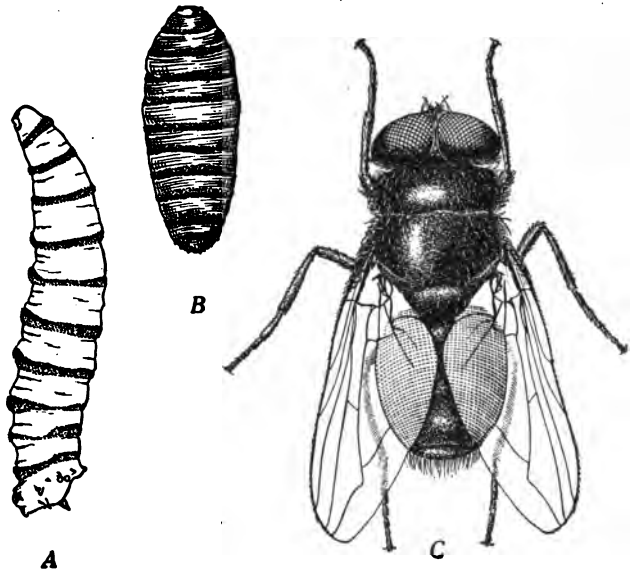


FIG. 80. *Formia regina*. A, larva; B, puparium; C, imago.

The subfamily *Tachininae* is one of the most beneficial of the order *Diptera*. The subfamily includes a number of species, several of which are found in California. In their larval form they are parasitic, and

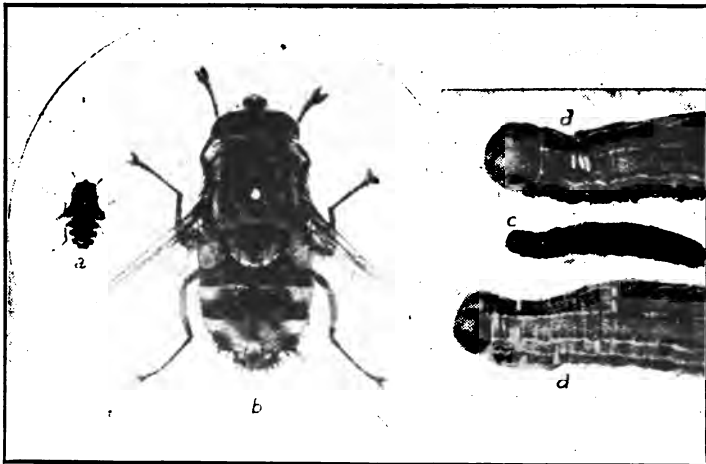


FIG. 81. Red-tailed tachina fly (*Winthemia l-pustulata*), a parasite of the armyworm. a, fly, natural size; b, fly, enlarged; c, armyworm, natural size, upon which eggs have been laid; d, parasitized armyworms, enlarged. (After Slingerland.)

lay their eggs upon the larvæ of other insects, largely on caterpillars, upon which the female fly lays her eggs. These eggs soon hatch out small footless grubs, or maggots, which at once proceed to bore their way

into the body of their host, where they remain until they have attained their growth. We have often been disappointed when, after caring for a choice specimen of caterpillar, until it passed into the chrysalis state, and were watching anxiously for it to come out, to have a small handful of Tachnid flies reward us for our pains.

In California one species of Tachinidæ is a most effective check upon the locust pest. This is the *Masicera pachytyli* Sk., and where there is a flight of grasshoppers these flies will be found in countless numbers, and the grasshopper which escapes them is rare. It is the natural enemy of the grasshopper, feeding most voraciously on the adipose tissues of its victim, but avoiding the vital parts. It feeds in the thorax and abdomen, and frequently three or four may be found in a single grasshopper. A grasshopper infested by these maggots soon shows signs of feebleness, ceases feeding, and dies in a short time, the maggots escaping often before the death of the host insect. The maggots, after extricating themselves from the grasshopper, enter the ground to pupate, and emerge in five or six days as perfect flies.

There is no more effective check upon cutworms and other lepidopterous pests than the *Tachina* flies.

The subfamilies *Sarcophaginæ*, the flesh-flies, and *Dexiinæ*, the nimble-flies, are of less importance to us.

The subfamily *Muscinæ*, however, embracing the house-flies, and other species equally obnoxious, forces itself more upon our consideration.

The house-fly (*Musca domestica*) is known by every one the world over. It is a highly sociable insect, and clings to mankind with a tenacity more to be repudiated than admired. Its breeding places are around stables, and a female will lay from 120 to 160 eggs. The larvæ attain their growth in from five to seven days, pass through their changes in another five to seven, and then make a line for our houses. Keep-

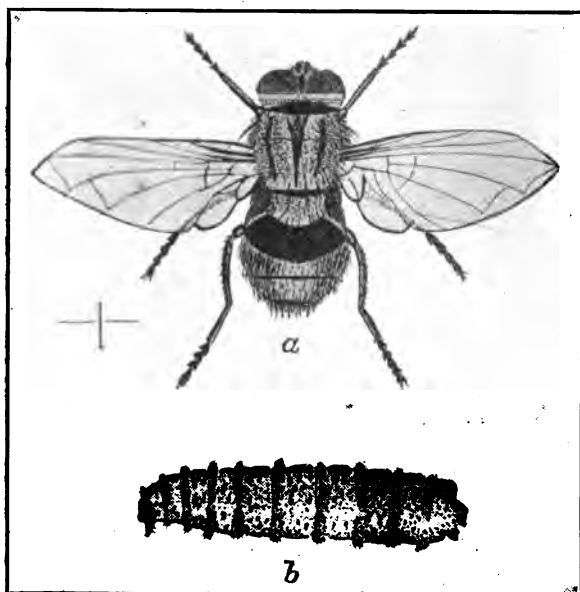


FIG. 82. Screw-worm fly (*Comptosia macellaria*), enlarged.
a, adult fly; b, larva. (After Francis.)

ing the stables clean, and removing all rubbish from around the house will do much to prevent them.

The stable-fly (*Stomoxys calcitrans*) resembles the house-fly, but its mouth parts are made for biting, while the house-fly is a sucker. Severe bites, and sometimes poisonous ones, are inflicted by this insect, for which the house-fly gets the blame.

The horn-fly (*Hæmatobia serrata*) is another dipterous pest of cattle.

The screw-worm (*Comptosia macellaria*), to which we have before alluded, belongs also in this subfamily; as does the blowfly (*Caliphora vomitoria*), the largest of the common species, with a deep blue, almost black body, always coming in swarms when there is an odor of cooking cabbage or decomposing meat.

The subfamily **Anthomyiinae** is a very large one, including the cabbage-maggot, onion-fly, and many others which infest vegetation. Some of its members are parasitic on other insects, and others infest decaying vegetation. Some of these resemble house-flies, but differ from them in structure.

The second division of the Muscidae is the **Acalyptrate Muscidae**, and this includes the fruit-flies, the dreaded *Trypeta ludens* among others.

Most of the flies belonging to the subfamily **Trypetinae** are small, although some of them are at least medium in size. They are characterized by their peculiar wing markings, which are shaded, mottled, banded, or striped. They vary in color

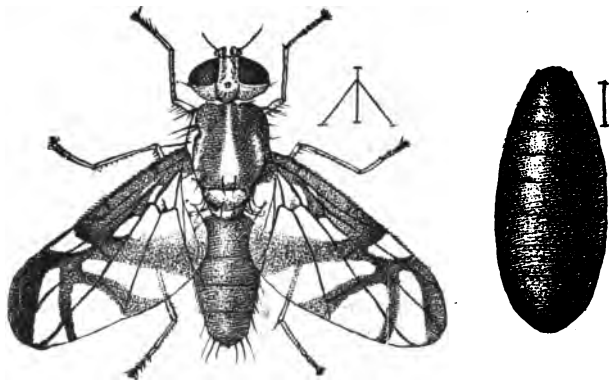


FIG. 83. *Trypeta acidusa*. Puparium at right, adult at left, greatly enlarged. (After Howard.)

from light brown to nearly black, and the family is well represented in the United States. It must not be supposed that because *T. ludens*, *T. pomonella*, and several others of our fruit pests belong to this family, all are pests on fruit. It is true that most of the fruit-flies belong here, but a very large number of the species live in galls which they form in the stems of wild plants, and are not noticeably injurious.

The cheese-maggot (*Piophilæ casei*) belongs in this group, as do also the vinegar or pomace flies—small, yellowish flies, common about decaying fruit.

The family **Hippoboscidae** includes the louse-flies. Some of these are winged and some wingless. They are parasitic upon birds and mammals. The best known member of this family is the sheep-tick, a wingless species, which lives upon sheep.

The family **Nycteribidae**, or bat-ticks, are, as their name implies, parasitic on bats. They, too, are a wingless species.

The family **Braulidae** includes the bee-louse, a minute wingless creature, infesting the honey-bee.

Order SIPHONAPTERA.

This is an order erected to take in the fleas. These insects have many peculiarities in common with flies, and at one time were considered as degraded Dipteron. The order contains but a single family, **Pulicidae**. There are a number of species, however, afflicting various animals. The dog and cat have their special fleas, and man another, the latter being the *Pulex irritans*, a description of which is not necessary for California readers.

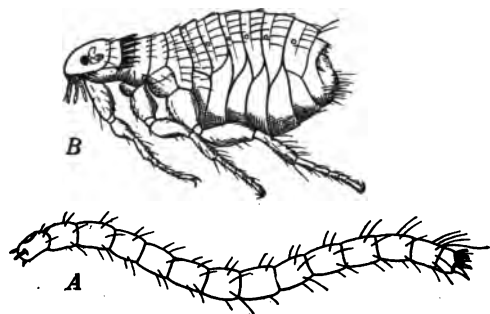


FIG. 84. Cat and dog flea (*Ctenocephalus canis*). A, larva (after Kunkel d'Herculais); B, adult. Length of adult, 2 mm.

The *Chigoe*, a small species, common in warm climates, is sometimes a very serious pest. The female has a habit of burrowing into the flesh, between the toes of the natives, or others, when opportunity

allows. In this position, with her abdominal end protruding, she swells with eggs to the size of a pea, when the eggs are obtruded and shed on the ground. Unless removed, these pests sometimes cause great suffering.

Order COLEOPTERA.

(The Beetles.)

The Coleoptera, or beetles, are, perhaps, not so familiar to the general observer as the butterflies and moths, although they outnumber them in species two to one, for they are generally obscure in their habits in both larval and adult stages, and when seen are usually avoided on account of their unfriendly, or, in some cases, disagreeable aspect. But they are so numerous, over 12,000 species being known, and so easily collected and preserved, that the amateur collector of insects is attracted to them nearly as much as to the Lepidoptera.

Beetles are characterized by the possession of a pair of horny wing-covers, called elytra, which meet in a straight line down the back, and beneath which is a single pair of membranous wings. They possess biting mouth parts, and the metamorphosis is complete. The earwigs are the only insects that might be mistaken for beetles, but as they possess a pair of pincers-like appendages at the end of the body, they may be readily distinguished from them.

The name Coleoptera is derived from the Greek *coleos*, a sheath, and *pteron*, a wing. The name refers to the sheath-like structure of the elytra, which were formerly believed to be modified wings, but which are now known to be homologous to the plates, or paraptera, which exist at the bases of the wings of the lower orders of insects. The true wings are membranous, and are efficient organs of flight in most species. When at rest they are folded beneath the elytra. In those species which have no true wings, the elytra serve only as a protection to the soft abdomen. The mouth parts are evenly proportioned, no part being over-developed at the expense of others, as in the Lepidoptera or Hymenoptera. The upper lip, or labrum, is usually distinct; the upper pair of jaws, or mandibles, are strong and fitted for seizing or gnawing; the lower jaws, or maxillæ, are composed of several distinct pieces, and bear prominent palpi; the lower lip, or labium, is also complicated in structure, and bears prominent palpi. The antennæ of beetles are extremely varied in form, being serrate, clavate, moniliform, or irregular, as the case may be. The tarsi, or feet, have from three to five joints, the last joint usually terminating in a pair of claws.

Since Coleoptera possess no easy means of identification, entomologists have had to separate groups and species by means of obscure specific differences in the structure of organs and parts of the body. The antennæ, mouth parts, and sclerites or plates of the body are usually employed, but such a mass of technical terminology has, of necessity, piled up on this account that the ordinary student of Coleoptera is much mystified.

The eggs of beetles are laid where the larvæ, upon hatching, will find an abundance of food suited to their needs. It may be on leaves, twigs, decaying logs, carrion, fresh water, or underground. The larvæ are known as grubs, wireworms, water-tigers, and the like. They usually possess six thoracic legs (some species have more), biting mouth parts, and simple eyes. The larval life lasts from a few weeks in some species to three years in others. After several molts they change into pupæ, either underground or in or on the food, using the last larval skin as a pupa case, or constructing a rough cocoon of earth and bits of wood and vegetable matter.

Only such of the eighty families as possess especial interest or economic importance can be treated, even briefly, in a short discussion.

The order is divided into two primary groups or suborders, *Coleoptera genuina* and *Rhyncophora*. *Coleoptera genuina* includes the typical beetles, with the mouth parts all present, and the head not elongated into a beak or rostrum. In the *Rhyncophora*, or snout beetles, the head is elongated, the labrum is indistinct, and the palpi are reduced to small processes. These two suborders are further divided into sections, tribes, families, genera, and species.

Suborder COLEOPTERA GENUINA. Section PENTAMERA.

The beetles in the section Pentamera all have five tarsal segments in all the feet. The **Adephaga**, one of the four tribes in this section, are the carnivorous beetles, and embrace four important families.

The members of the family **Cicindelidæ** are characterized by their metallic colors with light markings on the wing-covers, their graceful forms, rapidity of movement, and alert habits. They are commonly seen running and flying swiftly about sandy, sunny places. Both larvæ and adults are noted for their rapacity and ferocity, and these traits, combined with the curious markings on the elytra, have given them the name of tiger-beetles. The larvæ of tiger-beetles are repulsive in appearance, possessing large heads, which are bent at right angles downwards from the body and furnished with immense jaws and sprawling legs. They live in the sand in vertical burrows several inches deep, and in these they lie in wait ready to grasp any unwary insect that comes within their reach. To keep themselves from being pulled out by a larger insect than



FIG. 85. Tiger-beetle (*Cicindela rapan*).

themselves, they possess two strong small hooks on the back of the fifth body segment. The pupal stage is passed in the burrow, also in the last larval skin. The tiger-beetles, especially the larvæ, are beneficial to the fruit-grower, as they devour quantities of injurious caterpillars.

The **Carabidæ** are a family of flat, smooth beetles, usually shining black, greenish or brownish in color, with small heads, prominent slender antennæ, sharp mandibles, clubbed antennæ and conspicuous eyes. They are active and swift runners, ready to bite when caught. Most of them hide by day under boards, stones and the like, seldom taking to flight, and hunting their prey at night. The larvæ of many species live in the ground, where they destroy quantities of burrowing insects. The pupal stage is passed in rough cells in the earth, the emerging adults pushing their way to the surface.

The "searcher" or "caterpillar hunter," *Calasoma scrutator*, is one of the most familiar and beneficial of the Carabids. It is especially

destructive to tent-caterpillars, climbing the trees at night and feeding on them. Other species are predaceous on cankerworms and cutworms.

The bombardier-beetles (genus *Bruchina*) possess an organ at the tip of the abdomen by which when disturbed they spurt out, "with a popping sound and puff of smoke," an ill-smelling, acrid fluid. *Harpalus* is a large genus, any species of which destroys large numbers of the larvæ of the codling-moth and plum-curculios.

The **Dytiscidæ** are a family of carnivorous water-beetles of some three hundred species, common in all our streams and ponds, many of them from one to two inches long and quite conspicuous. They possess a single pair of eyes, long, slender antennæ, are flatly convex in shape and brown or black in color; the swimming hind legs are long, broad, and heavily fringed with hairs, and their air supply under water is carried in a bubble under the elytra, held in by means of fine hairs. The larvæ are long and slender, and on account of their voracity are called water-tigers. They breathe through a pair of spiracles at the top of the body, coming to the surface frequently for the purpose. The pupal stage is passed in a rough cocoon in the bank of the stream or pond.



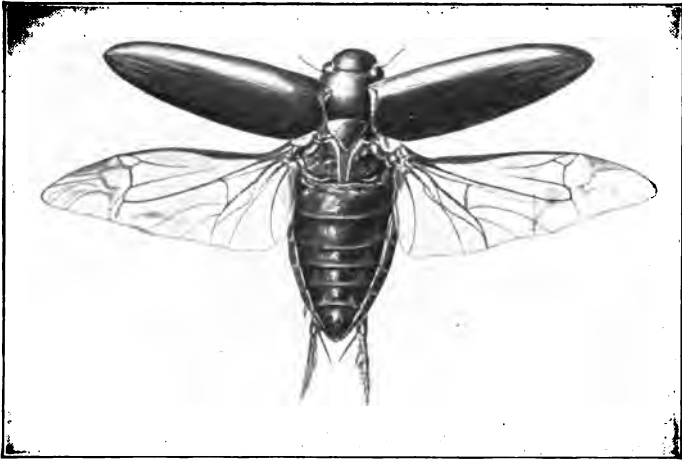
FIG. 86. *Calasoma* sp.

The **Gyrinidæ**, or whirligigs, are the small, metallic, steely black beetles seen swimming in circles on the surface of ponds and still pools. They are peculiarly characterized by the possession of compound eyes on each side of the head, which are distinctly divided into two parts by the sharp lateral margins of the head. They are of slight economic value, though destroying some mosquito larvæ.

Tribe **Clavicornia.**

This tribe comprises those beetles which have clubbed antennæ.

The family **Hydrophilidæ** are the "water-scavengers," usually black in color, though some have orange or red markings along the margins, convex above, flattened below, smooth and polished, and possessing short antennæ, which are clavate or clubbed. Certain of the smaller species are small, and have a rough body wall, and crawl on the bottom of ponds and streams instead of swimming, and still others are land forms. One species, *Hydrophilus triangularis*, is often seen flying about electric lights. All live on decaying matter, but are of slight economic importance.

FIG. 87. *Hydrophilus triangularis*. Natural size.

The family **Staphylinidæ**, or rove-beetle family, is a large and widely distributed group, its members being characterized by the possession of short, leathery wing-covers, which leave the abdomen exposed. They live in decaying animal or vegetable matter, excrement, or in flowers.

In the spring, certain tiny flower-inhabiting forms take to flight in great swarms, get in the eyes of travelers and become very annoying on account of their acrid body-fluids.

FIG. 88. Rove-beetle (*Staphylinid* sp.).

The **Silphidæ**, or "burying-beetle" family, are found on carrion and in fungi. The antennæ are terminated by a short spherical club, in which are the very sensitive organs of smell, and the wing-covers are slightly shortened. The thick-bodied beetles, black marked with red, and with the habit of digging under small animals until they are buried, belong to the genus *Necrophorus*, and are the burying-beetles proper.

The genus *Silpha*, or roving carrion-beetles, are short, broad, flat, black in color, and have longitudinally grooved elytra.

The **Cucujidæ** are a family of small beetles, light brown in color, flat and narrow in shape, well fitted for their habitat under the bark of trees. One species, *Silvanus surnamensis*, the saw-toothed grain-beetle, infests stored grain and dried food products of all sorts.

The **Dermestidæ** are the beetles commonly known as the buffalo-moths and carpet-beetles. They are small, stout, oval forms with weak legs, and feed in all stages on stored animal and vegetable products, dried insect specimens, furs, feathers, stuffed animals, and on cheese

and dried meats. Among the worst pests in this family are *Anthrenus scrophulariæ*, the carpet-beetles, known in the larval stage as the buffalo-moth; *A. varius* and *A. museorum*, the museum pests; and *Dermestes lardarius*, the larder-beetles.

The family **Parnidæ** are generally known as "water-pennies," on account of the flat, crustacean-like larvæ, which cling to stones. The adults are non-swimming, but crawl about on submerged objects.

Tribe **Serricornia.**

This tribe is composed of beetles with slender, serrated, saw-toothed antennæ.

The **Buprestidæ** is an important Serricorn family, both economically and numerically, its members being commonly known as the metallic wood-borers. These beetles have a compact, elongate body, short, serrate antennæ; the head is deeply inserted in the prothorax, and they are always metallic and iridescent in their coloration. Their larvæ are flat-headed, legless, tadpole-shaped wood-borers, making broad, shallow galleries and chambers under the bark of trees.

The apple-tree borer (*Chrysobothris femorata*) is a greenish-black beetle, half an inch long, which lays its eggs on the bark of apple, peach, plum, and several forest trees. The newly hatched larvæ bore through the bark to the sapwood, where they burrow around and often girdle the tree. The Sinuate pear-borer is another very serious pest in the Eastern States.

The **Elateridæ** resemble the Buprestidæ in shape, but their lack of metallic colors, being usually blackish, brownish, or grayish, and the

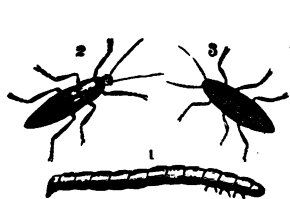


FIG. 90. Click-beetles (*Elaterids*) and larva (wireworm).

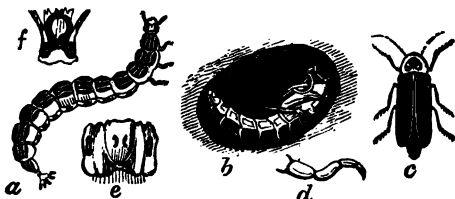


FIG. 91. Firefly (*Photinus pyralis*). a, larva; b, pupa in underground cell; c, adult; d-f, enlarged details of larva.

backward projecting angles of the prothorax, readily distinguish them from that family. On account of their power of springing up in the air when laid down backwards, they are called click-beetles. The larvæ are the "wireworms," and are long, slender, slightly flattened, and

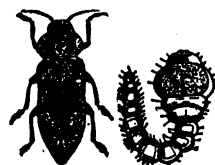


FIG. 89. Flat-headed apple-tree borer (*Chrysobothris femorata*).

leathery in texture. The larvæ live underground, and require two or three years to complete their growth. They are very destructive to sowed grain, root crops, meadow land and strawberries.

The insects commonly called fireflies are not flies at all, but beetles belonging to the family *Lampyridæ*. Only a few species are luminous, however, and these belong mainly to the genus *Photinus*. (See Fig. 91.)

The soldier-bugs are diurnal members of this family, of the genera *Chauliognathus* and *Telephorus*. *T. bilineatus* does much good in the Eastern States, as it eats quantities of plum-curculio larvæ.

The family *Cleridæ* are called "checker-beetles," or "flower-beetles," from the conspicuous black, white or red checkered markings on the body, and from their habit of living on flowers. The antennæ are serrate or slightly clubbed, and from the slenderness of the body and their habits of running swiftly about they look decidedly ant-like. With one exception, those of the genus *Necrobia*, the larvæ are all predatory on the larvæ of wood-boring insects and in bees' nests. *Necrobia rufipes*, the red-legged ham-beetle, lives on ham and other stored animal products; but, on the whole, the family is a very useful one.

The *Ptinidæ* are nearly all injurious forms, living on dried vegetable matter. They are small brownish beetles, with strange tastes in the selection of foods. The drugstore-beetle (*Sitrodrepa panicea*) attacks all sorts of drugs and herbs, many of them noxious and poisonous to us. *Lasioderma serricornea* lives on tobacco in any form, and is called the cigarette-beetle. Others are destructive to books and paper, or are borers, such as the apple-twigg borer. Certain species, belonging mainly to the genus *Aniobium*, have gained the name of "death watches," on account of their habit of rapping their heads against wood or some hard object.

Tribe *Lamellicornia*.

This tribe contains two families, the *Lucanidæ* and the *Scarabæidæ*.

The *Lucanidæ* are rather rare, curiously formed beetles, with elbowed, clubbed antennæ, and large, often branched mandibles. From the latter character they have received the name of stag-beetles. The larvæ are white grubs living in decaying wood, while the adults live upon honey-dew, and on sap which flows from wounds in trees.

The *Scarabæidæ* is, numerically, a very large family, and its numbers vary greatly in shape, size, and feeding habits. They all have antennæ with a club at the tip composed of from three to seven lamellæ, and the fore tarsi are formed for digging. The larvæ are white grubs, which live in decaying vegetation or excrement, or in the ground on

the roots of plants. There are two groups in this family: the scavengers, of which the tumble-bugs are examples, and the leaf-chafers, represented by the "May-beetles" and "June-beetles." *Macrodactylus subspinosus*, the rose-chaffer, a yellowish beetle with pale red legs, does great damage to roses and grapes and other flowers and fruits.

The genus *Lachnosterna* contains the "June-beetles," or "bugs," from whose attacks lawns and root-crops suffer.

The rhinoceros-beetles belong to the genus *Dynaste*, and are so named on account of large horns on the head, and another larger horn, accompanied by two smaller ones, projecting forward from the prothorax.

There are several genera of flower-beetles, one of the commoner forms being the "bumble flower-beetle," *Uphoria inda*. It is yellowish brown and hairy, and in early spring is seen flying near the ground with a loud buzzing noise.

Section TETRAMERA or PHYTOPHAGA.

This section comprises those beetles which, apparently, have four segmented tarsi, the fourth segment being so fixed with the third as to be indistinguishable. There are four families under this section, and among them are very many of our worst crop enemies.

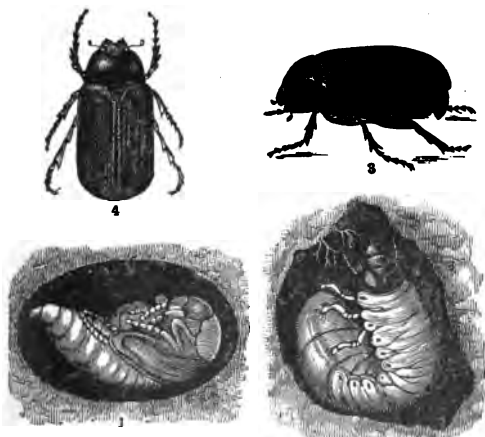


FIG. 94. June-bug or white grub. 1, pupa; 2, larva; 3-4, adults.

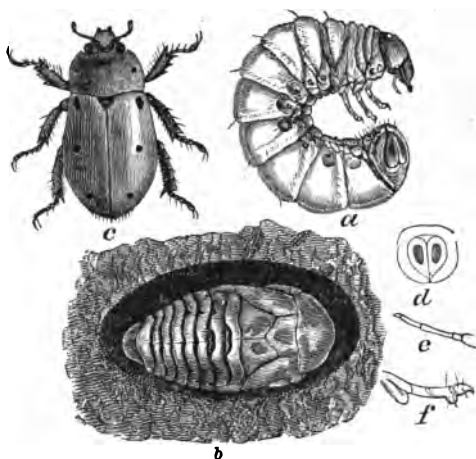


FIG. 92. Grapevine beetle (*Pelidnota punctata*). a, larva; b, pupa; c, beetle; d, antennae; f, leg, enlarged.



FIG. 93. Rose-chaffer (*Macrodactylus subspinosus*).

The family *Chrysomelidæ* is one of the largest of the beetle families and probably contains more injurious forms than any other. They are generally small, oval forms, strongly convex above, possessing small heads and widely separated antennæ. The adults, when disturbed, have

the habit of folding up the legs and dropping inert to the ground.

The Colorado potato-beetle, asparagus-beetle, and elm-leaf beetle are some very destructive species which have not yet reached California.

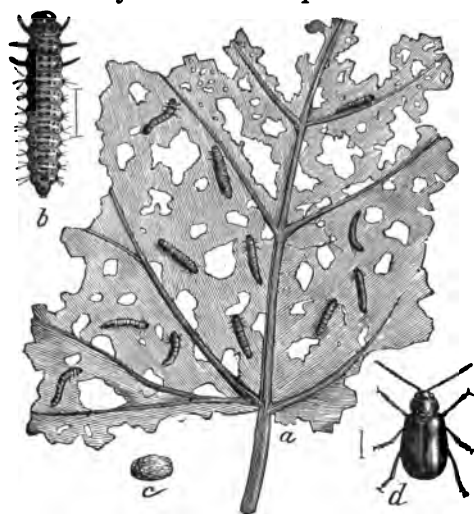


FIG. 95. Grapevine flea-beetle (*Haltica chalybeus*).

feeding on cucurbits, represent these destructive insects. *Lena californica* is a small blue beetle found on dock, and *Lena scripta* on willow.

The black-legged tortoise-beetle (*Cassida nigripes*) represents a genus of bright golden-colored Chrysomelids of a peculiar shape, which are most often found feeding on the leaves of the sweet potato.



FIG. 96. Black-legged tortoise-beetle (*Cassida nigripes*).

The family **Bruchidæ** is small, and consists of beetles which are short and chunky, with the elytra cut off behind, with small head, and thighs swollen as if from jumping, and which in all stages live on stored seeds.



FIG. 97. Bean-weevil (*Bruchus obtectus*).

Bruchus pisi, commonly known as the pea-weevil, and *B. obtectus*, the bean-weevil, are cosmopolitan species.

The **Cerambycidæ** have antennæ as long or longer than the body, and are primarily a wood-boring family, being commonly called the long-horned wood-borers. The bodies of these beetles are usually cylindrical and elongate, though some are flattened, and their mandibles are stout and sharp-pointed. The larvæ are known as the round-headed borers, to distinguish them from the flat-headed Buprestids. Over 600 species are known, most of them living in dead or dying wood, although some attack healthy tissue.

The round-headed apple-tree borer (*Saperda candida*) is a pale-brown beetle, with two broad whitish longitudinal stripes. The larval life is three years, the first part being spent in the sap-wood and the later, and pupal stages, in the heartwood. The "pruners" are species living in and eating out the hearts of twigs of maple, oak, apple, pear, plum, and other trees, so that the wind blows them to the ground.

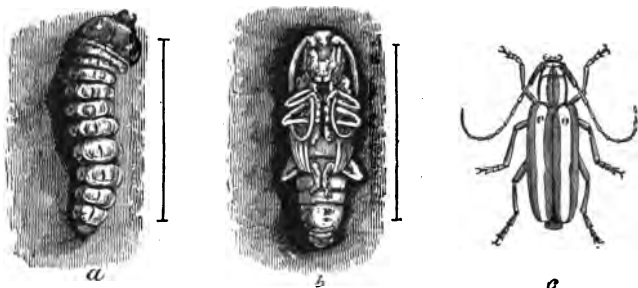


FIG. 98. Round-headed apple-tree borer (*Saperda candida*).
a, larva; b, pupa; c, imago

Our great sugar and yellow pines are attacked by a large Cerambycid, *Ergates spiculatus*. The genus *Prionus* has some large species, the larvæ of which are two and one half to three inches long and which live in the roots of apple and cherry trees, and of grape and black-berry vines.



FIG. 99. California pine-borer
(*Prionus californica*).

Section TRIMERA.

This section contains only one family, the all-important beneficial one, the *Coccinellidæ*, or ladybirds. They are small, hemispherical beetles, usually red or yellow with black spots, or black with red or yellow spots. The tarsi have only three joints, so that if confused with certain Chrysomelids, as they sometimes are, this character serves to readily distinguish them. With one exception, the genus *Epilachna*, they are all predatory, both larvæ and adults, on plant-lice, scale insects, and other soft-bodied plant-feeding insects. The larvæ are slender and fusiform in shape, with roughened spiny bodies, often prettily marked with blue, black, and orange.

Hippodamia convergens is a very common native form, feeding principally on plant-lice (aphids). It is yellowish red in color, with six black spots on each wing-cover. *Coccinella californica* is a similar form, but more rounded and lacking the spots. *C. sanguinea* is a small, blood-red form. *C. abdominalis* is the ashy gray ladybird with seven small black spots on the thorax and eight on each wing-cover. *Chilocorus bivulnerus*, the "twice-stabbed," is a large black ladybird, with a large red spot on each wing-cover, very destructive to the armored

scales. *Coccinella oculata* is a still larger form often taken for the "twice-stabbed" ladybird. *Exochomus pilatei*, "Pilate's ladybird," also resembles the "twice-stabbed," but the under side of the abdomen is black instead of red. It feeds on black scale, but does not increase rapidly. *Psyllobora 20-maculata*, the "20-spotted ladybird," is a common species, feeding on young scale and the red spider.

Of the ladybirds introduced by the State Commission of Horticulture, *Vedalia cardinalis*, *Rhizobius ventralis*, *R. twoombæ*, *Novius koebelei*,

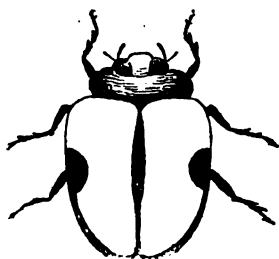
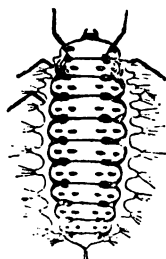


FIG. 100. *Novius koebelei*.



Orcus chalybeus, *Cryptolæmus montrouzieri*, *Scymnus vagans*, *S. marginicola*, *Rhizobius debilis*, *Rhizobius lopantha*, and *Hyperaspis lateralis* have proved the most successful. *Vedalia cardinalis* and *Novius koebelei* have completely subjugated the cottony-cushion scale. *Orcus chalybeus* is effective against

the yellow scale. *Rhizobius ventralis* is a very useful destroyer of the black scale. *Scymnus vagans* is an enemy of the red spider. *Rhizobius lopantha* makes some headway against the purple scale; and *Cryptolæmus montrouzieri* cleans up the mealy-bugs in greenhouses. The other species are general feeders.

If it were not for these industrious enemies of our fruit and vine pests, California would be far from ranking to-day the chief fruit-producing State of the Union.

Section HETEROMERA.

This section is a rather miscellaneous lot of beetles, including several small obscure families, as well as two large ones. All those beetles which have the front and middle feet with five tarsal segments and the hind feet with four are included in it.

The family *Tenebrionidæ* are the "darkling beetles." They are usually dark brown or black in color, oblong or oval in shape, have the head more or less inserted in the prothorax, and, on account of their long legs, are very awkward in their movements. Both adults and larvæ are scavengers, the latter much resembling wireworms in appearance. The common pinch-bug, *Eleodes* sp., which when disturbed stands on its head and emits an ill-smelling fluid, is a familiar type. The meal-worm beetle (*Tenebrio molitor*), bred by bird fanciers for food, and *Tenebrio obscurus*, found about stored grain products, are cosmopolitan species.

The family **Meloidæ** are called blister-beetles, because their bodies when dried and pulverized are used therapeutically as blisters. In the adult stage they feed on plant tissue, and are sometimes injurious. In the larval stage many are, however, markedly beneficial, such as the larvæ of *Epicauta vittata*, which live on the egg pods of grasshoppers. The life cycle of many species has reached a highly specialized development and their study is exceedingly interesting.

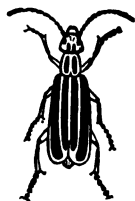


FIG. 101. Striped blister-beetle (*Cantharis vittata*).

The **Stylopidæ** is an obscure family, most of its forms being parasites on wasps.

Suborder RHYNCOPHORA.

The suborder Rhyncophora, or snout-beetles, consists of beetles characterized by the peculiar prolongation of the front of the head into a beak or snout, at the end of which the mouth parts are situated. The curculios, bill-bugs, and most of the weevils belong to this suborder, and are great pests, living as they do on vegetable matter, stored products, and the like.



FIG. 102. Fuller's rose-beetle (*Aramigus fulvif*).

The family **Ottorhynchidæ** are the beetles which have a scar on the front of the upper side of each mandible.

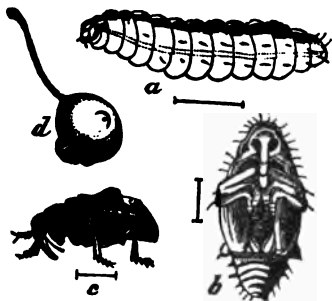


FIG. 103. Plum curculio (*Conotrachelus nenuphar*). a, larva; b, pupa; c, adult; d, curculio at work.

Fuller's rose-beetle, a species attacking roses and orange trees, is a familiar type.

The family **Curculionidæ** lack the scar, and are the typical curculios and weevils. The cotton-boll weevil, strawberry weevil, and the plum-curculio are well-known pests belonging to this family.



FIG. 104. Pine-tree scolytus (*Scolytus pyri*).

The **Calandridæ** include the bill-bugs and rice and granary weevils. The latter two forms, *Calandria oryzae* and *C. granaria*, are world-wide in distribution and do immense damage to stored grain.

The **Scolytidæ** are the engraver-beetles. According to Pinchot, the annual losses caused by these insects total nearly \$100,000,000. The Monterey pines of California are attacked by two species, *Dendroctonus valens* and *Tomicus plastrographus*, to such an extent that entire forests have been killed by them. Others, such as the fruit-bark beetle, attack and kill peach and plum trees.

Order **HYMENOPTERA.**

(Bees, Wasps, Ants, Saw-flies, etc.)

This, of all the orders, is the one which may be said to be wholly beneficial to man, for while, as there is a black sheep in every flock, there are injurious species in the Hymenoptera, they are so largely the exception to the rule that we may say that the order Hymenoptera is the one wholly beneficial order of insects. In this order we find the several species of honey-bees, which supply us with honey and wax; an immense number of parasitic insects, which keep down any redundancy on the part of the injurious species; and the ants, which act as scavengers. The whole of the wasp family are beneficial, for, in providing for their young, the larger members stuff their cells with spiders, caterpillars, and other insects, and they are all predaceous in some form. It is in this order, too, that we find the highest development of the social instinct, for many of the species are so constituted that they can not exist except in communities, and in these communities we find the most perfect system of division of labor imaginable. With the social bees, for instance, we have one mother bee, whose sole duty is to supply the eggs from which the stock of workers is to be kept up; the drones, or males, whose sole duty is to act as fathers of the hive; the third class are the workers, and these are again divided into outside workers, inside guards, nurses, and other classes, each of which has its special duties to perform, and upon the proper performance of which the welfare of the whole community depends—and they never fail in their duty. In this order, too, we find the only class of insects which care for their young. In all others the eggs are laid as it happens. Usually instinct directs the female to choose a position which will supply food for the young when hatched, but, this done, she is through with them and gives them no more care. But in this order we have species which diligently watch over the eggs, take charge of the young when hatched, attend to them, feed them with proper food, and watch over them in every stage of their growth until they have passed through all the changes, entered the ranks of the mature workers and are ready, in their turn, to perform the same duties for their successors.

The name Hymenoptera is compounded of two Greek words, *hymen*, membrane, and *pteron*, wing. The name is not altogether distinctive, however, as all insects possessing membranous wings are not members of this order, but all members of this order have four membranous wings. A peculiarity of this order is that the hinder pair of wings are provided with a series of hooks, with which they catch the fore wings, and thus the two pairs are connected closely together. Another feature is that while in all other insects the mouth parts are made for either biting or sucking, in this order they are so arranged as to be of use for both purposes.

The three divisions of the body are well defined. The head is, in many species, movable on the thorax, while the thorax is sharply divided from the abdomen, in some cases, as in the wasps, being joined by a mere thread-like process.

The metamorphosis of the Hymenoptera is complete. The eggs are not remarkable for either form or color, and are usually somewhat oblong. They are laid in various positions, according to species, in some cases being deposited in the bottom of cells prepared to receive them; in others, as in the parasitic species, being attached to or placed in the body of their victims. In all, except the two lower families, the larvæ are maggot-like creatures, footless, and incapable of extended motion, and, in many cases, wholly dependent for their existence upon the care of the adults.

This order is divided into two suborders, the *Terebrantia* and the *Aculeata*. The former comprises a number of parasitic insects, as the ichneumons, braconids, chalcids, etc., the gall-flies, saw-flies, etc.; while the latter includes the stinging forms, as bees, wasps, and ants.

Suborder TEREBRANTIA.

In the modern system of classification it has become the rule to commence with the lower forms and work upward to the higher, and, for this reason, the Hymenoptera, being recognized as the highest developed of any of the members of the insect world, is placed at the top of the list. In this arrangement the various orders and families may be compared to a pyramid, in which the less specialized, lower, and baser kinds form the foundation, and in which there is a constant ascent until the capstone is reached, and, in this case, this is the higher order of Hymenoptera. So, in accordance with this plan, the suborder Terebrantia, which is the less specialized of the two suborders, and contains the lower forms of the order, takes its place first in our consideration, and in this the lower families are first noticed.

Comstock gives us the following synopsis of the suborder Terebrantia:

THE BORING HYMENOPTERA. Suborder Terebrantia.

The Plant-eating Hymenoptera.

The Saw-flies. Family Tenthredinidæ.

The Horn-tails. Family Siricidæ.

The Gall-inhabiting Hymenoptera.

The Gall-flies. Family Cynipidæ.

The Parasitic Hymenoptera.

The Trigonalids. Family Trigonalidæ.

The Ichneumon-flies. Family Ichneumonidæ.

The Stephanids. Family Stephanidæ.

The Braconids. Family Braconidæ.

The Ensign-flies. Family Evanidæ.

The Chalcid-flies. Family Chalcididæ.

The Proctotrupids. Family Proctotrupidæ.

Family **Tenthredinidæ** (Saw-flies). In this family the females are provided with a pair of saws, which are concealed in a cavity of the abdomen when not in use. With these she cuts a slit in the leaves or stems of plants upon which she lay her eggs, and it is this fact which gives its common name to this family. The larvæ are small, slimy-looking insects, somewhat resembling caterpillars, but they have from twelve to sixteen prolegs, while caterpillars, with one exception, have but ten. They are a serious pest upon plants infested by them, and examples of this family

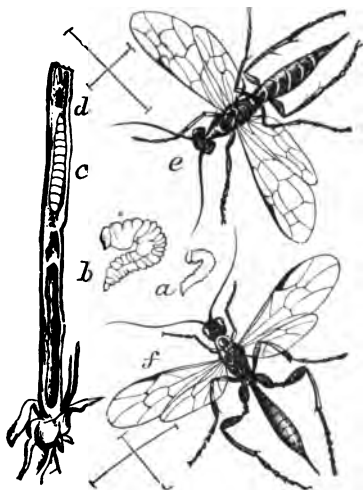


FIG. 105. Corn saw-fly (*Cephus pygmaeus*). a, larva; b, larva, enlarged; c, larva in wheat stalk; d, frass; e, adult female; f, its European parasite (*Pachynerus calcitrator*). (From "Insect Life.")

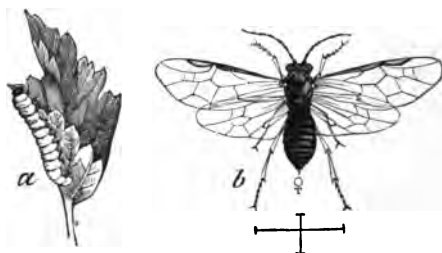


FIG. 106. Currant-worm (*Pristophora grossulariæ*)

may be instanced in our common cherry-slug (*Eriocampa cerasi*) (which also infests the pear), the rose-slug, and the currant-worm.

Family **Stricidæ** (Horn-tails). This family is closely connected with the foregoing family, but differs from it in the shape and uses of the ovipositor. Instead of being a sawing instrument, as in the former, it is a very complicated and effective boring tool, by means of which the female can drill a hole in the hardest wood, in which she deposits her egg. The habits of the larvæ are also very different, those of the horn-tails being boring insects, and they sometimes do great damage to forest timber and shade trees. Members of this family are of large size, the pigeon tremex (*Tremex columba*), which is not uncommon in our State, being as large around as a pencil, and sometimes an inch and a half in length.

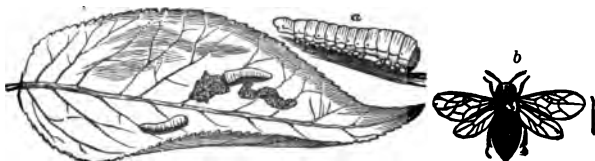


FIG. 107. Cherry-slug (*Eriocampa cerasi*). a, larva on leaf and larva enlarged; b, adult saw-fly.

These two families are practically all of this order which are injurious, or not beneficial to man. The gall-flies, which come next, when very numerous, may do some damage to vegetation, but the extent of this is trifling.

Family *Cynipidæ* (Gall-flies). In this family we have one of the mysteries of the natural world. Here we have a minute insect, in some cases almost microscopic in size. This insect will puncture a twig or leaf of a tree, and at once the whole character of the part so punctured is changed. In the oaks, for instance, we see galls known as oak apples, and often they are as large as big apples, and these are formed for the purpose of supplying sustenance to the tiny maggot of a gall-fly. What kind of fluid is injected to cause this change? It certainly is wonderfully powerful, as the amount injected must be so infinitely small as to be past our comprehension, for it is but a part of the insect and this is not large enough to be noticed. More than this, each species creates a special kind of gall, and an entomologist can tell what species of insect did the stinging by the shape, color, and general appearance of these strange swellings. Now, how is it that the plant will accommodate its growth to the peculiar requirements of each one of the different species of these minute insects?

It must not be understood, however, that all the members of this family are gall-makers, or that there are no galls caused by other insects. In fact many of the other orders have gall-makers, as the aphids, the mites, etc.; but there is this difference: in other galls there are external openings, while in the galls made by members of this family they are closed and contain the larvæ of the insect until they have attained their growth. In some cases the insect goes through its transformations within the gall, and in others it makes its escape and changes in the earth.

Family *Ichneumonidæ*. We have now come to a family of especial interest to the fruit-growers and farmers of California as well as elsewhere, for in the *Ichneumonidæ* are found the greater number of our beneficial insects; that is, they are of benefit to us, as they prey upon species which devour and destroy our vegetable products. It is to this family that Swift's oft misquoted lines apply:

"Naturalists observe, a flea
Hath smaller fleas that on him prey,
And these have smaller still to bite 'em,
And so proceed *ad infinitum*."

It should be borne in mind that there are two classes of beneficial insects, the *parasitic* and the *predaceous*. In the latter the insect pounces upon his victim wherever he catches him, that is, if he happens to be hungry, and devours him on the spot. The parasitic insects, however, have a neater way of doing business. In their proceedings they are not so coarse as the predaceous varieties, although they accomplish their work more effectively. They attach themselves early in life—in fact, the mother usually brings about the match—and, once attached, they remain until there is nothing left of their victim worth

bothering about. They are quiet and insidious in their efforts, but never let go. Some of them get on the inside of their host, in which case they eat him out of house and home before they quit; in other cases they take an attachment on his outside and cling closer than a brother so long as he has a drop of blood in his body. But, however they do it, the result is the same to us; they get away with our foes, so we declare them our friends. But, bearing out Swift's doggerel, there

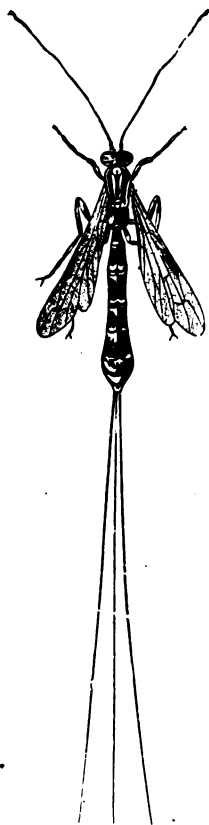


FIG. 108. *Thalessa lunator*, ichneumon parasite of pigeon tremex (*Tremex columba*).

are other parasites on these—secondaries, or hyper-parasites, we call them—and some parasites on these again—tertiaries. So that, in importing beneficial insects, we are always very careful to see that there are no secondaries to escape and prey upon them before they are turned loose. Usually, when the egg is laid upon the body of the victim insect, as soon as it is hatched the young larva proceeds to work its way to the inner portions of its host, where it lives secure and waxes fat on his substance. By a strange instinct, however, it carefully avoids the vital portions, and so the host insect lives in misery until its parasite has acquired its growth, when it dies.

While some of the members of this family are of small size, many of them are large, for parasitic insects. The *Caliephilates messer* Grav., of which we give an excellent colored illustration elsewhere, is a member of this family. This is a new species

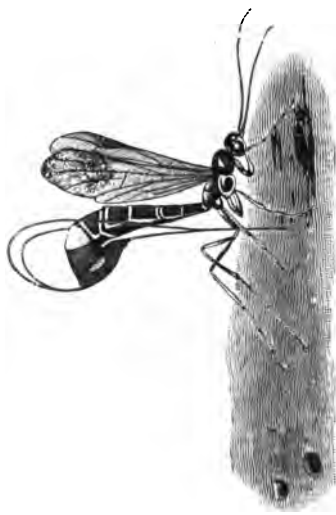


FIG. 109. *Thalessa lunator* drilling a hole in a tree-trunk in order to deposit eggs in the burrow of the pigeon tremex (*Tremex columba*).

in the United States, introduced for work on the codling-moth, of which it has been found a very effective parasite.

The females of some species of this family are remarkable-looking insects, having an exaggerated ovipositor, which appears like a long tail. This, when folded, looks like one piece, but is really composed of three pieces: the ovipositor proper, and two guards, which form a sheath. The ovipositor itself is composed of three parallel pieces, one

above and two below, joined together; near the end they are toothed like a saw, and between them is the egg passage. In the larger species, the females seem possessed of a special sense by which they ascertain whether their victim has already been attacked. If it contains an egg, they abandon it for another. This, for the reason that the food supply would not be sufficient for two large larvæ. With the smaller species, however, it is not uncommon for the female to lay a number of eggs on one victim. But it is not alone in their larval stage that insects are attacked by parasites, for they are subject to it at any stage of their existence, from infancy to age. Even in the egg, they are not immune, for there are egg parasites—minute insects, which lay their eggs within the eggs of other insects, which are eaten out by their internes.

The family **Stephanidæ** contains a few rare insects of no importance in this discussion.

The family **Braconidæ**, however, is a different matter, for this is a very extensive family of, generally, very small to medium sized insects, containing several thousand described species. All are parasitic on other insects, and in this we find many of the secondary and tertiary parasites. This family, in the older classifications, is included in the Ichneumonidæ, but well-defined differences in the two classes have led to the creation of the new family of Braconidæ. As parasitic insects, however, their habits of life are very similar, and to their efforts is largely due the fact that we are not entirely eaten out by the destructive pests. One of the chief checks on the aphids of our gardens is a minute member of this family, the genus *Aphidius*. Examine a twig or leaf infested with plant-lice, and you will see many of them bloated and white. Look closely and you will see a minute circular hole in the abdominal end. It is from this hole that the insect, after having eaten out the aphid, and gone through all its changes on the inside of the victim, has escaped. Gather a few



FIG. 110. Tomato-worm (*Phlegethontius sexta*), bearing cocoons of the parasitic *Apanteles congregatus*. Natural size.

of these aphid-infested leaves or twigs, place them in a small vial, and cover it with gauze. In a short time you will find numbers of a tiny, dark-colored insect, looking like a miniature wasp. This is a Braconid of the genus *Aphidius*. There are millions of them at work; each one eats an aphid, and afterwards lays hundreds of eggs on other aphids, which, in their turn, eat up their hosts. These insects of the parasitic class are usually small, and often so minute as to escape observation; but insignificant as they appear, we owe our very existence to them, for without their constant efforts we would be reduced to a condition of starvation by the hordes of pests, which, having no checks, would increase with enormous rapidity and soon overwhelm us like a flood.

The family *Evanlidæ* is a small one, closely connected with the *Ichneumonidæ*, but differing from them in structural characters. Its habits are similar, as it is parasitic.

The family *Chalcididæ* is an immense group, composed largely, but not wholly, of parasitic insects. As a rule, the members of this family are exceedingly small, many of them being microscopic, and some even requiring a high-power lens to bring them into view. Notwithstanding

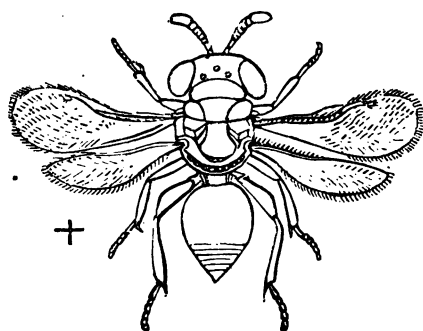


FIG. 111. *Tomocera californica*, a chalcid parasite of black scale (*Saissetia oleæ*). Female, very greatly enlarged.

their minute size, however, they rank among the best friends the fruit-grower has, for they make up in numbers what they lack in size, and to the destructive pests of the fruit-grower they are as "terrible as an army with banners," for within the ranks of the *Chalcididæ* is comprised the largest number of species of any of the parasitic Hymenoptera, extending into many thousands. The members of this order are very small, and, as a rule, lack the attractive beauty of some of the larger insects, and so have

been much neglected by entomologists. Dr. L. O. Howard, Chief of the Bureau of Entomology of the United States Department of Agriculture, has devoted much time to the study of this family, and to him, more than to any one else, science is indebted for its knowledge of this interesting and valuable group. Most of the species are parasitic, and most of them confine their attacks to one class of insects. Some of them, unfortunately, attack some of our beneficial insects, so that they are not wholly beneficial from our viewpoint.

In speaking of this family Professor Howard says: "Nowhere in nature is there a more marked example of the co-relation between

structure and habits than occurs in this family. This co-relation descends to the relation between the parasites and their hosts, so that it is possible for an experienced person on seeing a new species of Chalcid fly to tell precisely what kind of an insect it will be found to be parasitic upon. For example, the species of the genus *Copidosoma* are always parasitic within naked caterpillars. Those of the genus *Bothriothorax* are always parasitic in small dipterous larvæ. The economic importance of the group is great. They are the most effective parasites of many of our most injurious insects. For example, in a certain year in the cotton fields of northern Florida ninety-five per cent of the eggs from which would have hatched the voracious cotton-caterpillar were killed by the minute Chalcid parasite, *Trichogramma pretiosa*."

In our own State, the different species of this family form one of the most efficient checks on scale pests, usually burrowing into the scale and eating it out. How exceedingly minute some of them are is indicated by the fact that the red, yellow, and San José scales are all parasitized by members of this family, and, within the bodies of these insects, none of which are larger than the head of a pin, these little flies have ample room to live, grow, pass through all their changes, and emerge as perfect insects. We have often found from three to five parasites belonging to this group snugly ensconced within the body of a soft brown scale, and there was ample room for all without crowding.

Some of the Chalcids attack larger insects, and the cabbage-butterfly is largely kept down by the efforts of one of them, *Pteromalus puparum*, which lays its eggs on the caterpillar and reduces it to a state of "innocuous desuetude." One branch of the family closely approaches the gall-flies in structure and habits.

The family **Proctotrupidæ** contains the smallest members of the Hymenoptera. They are all parasitic, many of them being parasitic on the eggs of other insects. How small they are may be understood by the statement that, in some cases, as many as half-a-dozen of them will live and pass through all their changes within one minute egg of an insect, moth, butterfly, or bug. Some live in the larvæ of other insects, some exist wholly in the nervous system, others in the digestive tract. The largest of them is not over one twenty-fifth of an inch in length, while the smallest (*Alaptus excisus*) measures between six and seven one-thousandths of an inch.

Suborder ACULEATA.

We now come to the second branch or suborder of the Hymenoptera, which includes the species armed with stings. Most of our readers have made acquaintance with them, as the group includes the wasps,

hornets, bees, and ants. These are divided into families as follows, according to Comstock's classification:

THE STINGING HYMENOPTERA. Suborder Aculeata.

The Pelecinus. Family Pelecinidæ.

The Cuckoo-flies. Family Chrysididæ.

The Ants. Superfamily Formicina.

Family Formicidæ.

Family Poneridæ.

Family Myrmicidæ.

The Digger Wasps. Superfamily Sphecina.

The Velvet-ants. Family Mutillidæ.

The Scoliids. Family Scoliidæ.

The Sapygids. Family Sapygidæ.

The Spider-wasps. Family Pompilidæ.

The Thread-waisted Wasps. Family Sphecidæ.

The Ampulcids. Family Ampulcidæ.

The Larrids. Family Larridæ.

The Bembecids. Family Bembecidæ.

The Nyssonids. Family Nyssonidæ.

The Philanthids. Family Philanthidæ.

The Mimesids. Family Mimesidæ.

The Mellinids. Family Mellinidæ.

The Pemphredonids. Family Pemphredonidæ.

The Crabronids. Family Crabronidæ.

The True Wasps. Superfamily Vespina.

The Guest Wasps. Family Masaridæ.

The Solitary Wasps. Family Eumenidæ.

The Social Wasps. Family Vespidæ.

The Bees. Superfamily Apina.

The Short-tongued Bees. Family Andrenidæ.

The Long-tongued Bees. Family Apidæ.

It is in this suborder that we find the fullest development of the social instinct. With the social bees, wasps, and ants, every interest is sacrificed for the good of the community. Here

"None is for himself,
But all are for the state."

None of the members of this suborder are of direct importance to us, being beneficial only incidentally. The wasps are all predaceous, many of them preying upon the larvæ of injurious species, while the work of the bees is too well known to need enlargement in these pages. Probably we owe more to this group for their work in the pollenization of plants and fruits, perhaps in the cross-fertilization of species—hybridization—and probably even the production of new species, than for any

other benefits they render us. Were it not for their labors in this direction, aided by other insects, true, and perhaps to some extent by other means, it is not improbable that a very large part of the vegetable world would perish and man and other members of the animal kingdom suffer correspondingly. A cursory glance at the various families comprising this suborder is, therefore, all that is required in this place.

The family **Pelecinidæ** is a very small one, in which the distinguishing peculiarity is the great length of the abdomen in the female.

The family **Chrysididæ**, better known as the cuckoo-flies, have the habit of the bird after which they are named, of laying their eggs in the nests of other wasps and leaving them to be fed by the owner of the nest. As the larva develops, it either turns out the proper occupant of the cell or devours it. They are beautiful insects, the body being a brilliant metallic green.

Superfamily **Formicina.** (Ants.)

The ants have been erected into a superfamily called Formicina, and this superfamily is divided again into three families: the **Formicidæ**, **Poneridæ**, and **Myrmicidæ**. Ants are so distinct from all other insects, and so well known to most people, that no description is needed here. There is but one other class of insects likely to be mistaken for them, the Termites, which are not ants at all, although called "white ants." These do not at all resemble ants in appearance, either in form or in color, but being communistic insects have somewhat the habits of ants in this regard. Termites resemble ants in the fact that they congregate together in immense numbers, and are divided into different classes, each class having separate and well-defined duties to perform in the community. Aside from this their habits are entirely different.

All the species of ants are composed of three classes of individuals: males, females and neuters, or workers, which latter are really undeveloped females. All ants live in communities of greater or less extent, and in some cases these colonies are exceedingly populous. By what system of laws these densely populated communities are governed is unknown, but it is known that each class performs its appointed duties without let or hindrance and that all move smoothly and harmoniously. The workers perform all the work of the colony, and their numbers exceed the other classes many times over. There are usually several perfect females whose sole duty is to maintain the strength of the colony, and for a short time during the early summer a great number of young females and males are produced. These quit the nest together, never to return. They are the ones which found new colonies, and out

of thousands which start forth, vast numbers of them perish, falling a prey to birds and other causes. There is much that is fascinating in the life of an ant, and these insects have been a great favorite with entomological students even from the time of Solomon, as is indicated by his advice: "Go to the ant, thou sluggard; consider her ways and be wise." Many books have been written of them, and when we consider their intelligence and that in many respects they resemble man, it is not strange that we should be interested in them. We find among them a perfect system of government; also a highly specialized division of labor, many of our trades being represented, such as architects, builders, agriculturists, tailors, masons, and many other trades corresponding to those followed by man. The rare intelligence exhibited by ants in attending to and caring for their young is astonishing. They watch the eggs and larvæ night and day, and remove them from place to place, as they require more or less light, warmth, and moisture. When an ants' nest is disturbed the workers first of all secure the young and take them to a place of safety, this instinct being even greater than that of self-preservation, for they will risk the greatest dangers and their own lives for the eggs and cocoons of the young insects. That they are able to communicate and transmit intelligence is evident, too, and this is done by means of their antennæ. They play like children when they have leisure, and have so many striking peculiarities that there is a charm in them for those who are not interested in entomology.

They have, however, little economic importance, for, except incidentally, they are neither hurtful nor beneficial. If anything rather the former, as, in their efforts to get the exudation of honey-dew from aphids and scale-bugs, they often spread these insects into new locations, and they sometimes prey upon the soft larvæ of some of the lady-birds, and thus keep down our beneficial insects. The small red ant found in the house becomes a pest by reason of its enormous numbers, which increase in the summer. This is essentially a domestic species, having its nests in the walls and floors of our houses. It is sometimes very difficult to trace it, but usually by careful watching the location of the nest can be found, when it may be driven out by the application of coal oil to the runways.

Superfamily **Sphecina.** (Digger-wasps.)

The next superfamily is the Sphecina, and is composed of the solitary wasps, the digger-wasps, or *Fossors*. This name is given to them from the fact that each female makes a nest for herself, usually by burrowing in the ground or boring into wood. Some, as the so-called mud-daubers, construct tubes, while others use any suitable tunnels they can find, or even utilize the hollow stems of plants, in which to deposit

their eggs and provide for their young. These nests are usually provided with food for the young wasps in the form of the preserved bodies of other insects or spiders. Many species provision their nests with caterpillars, others with spiders. The parent wasp possesses some kind of fluid which she injects into the victim, and which renders it apparently senseless, but which, instead of killing, preserves its life, and it will remain in this condition perfectly fresh until required by the larvæ of the wasps for food.

Comstock gives us fourteen families under the superfamily Sphecina, to most of which only a passing allusion is necessary.

The family **Mutillidæ** are the velvet-ants. The females are wingless and strongly resemble ants in appearance, but their bodies are covered with a dense growth of hair, which has given them their common name.

The family **Scoliidæ** very strongly resembles the foregoing family. Members of this family do not build a burrow, but find the larvæ of other insects in the ground, and upon these they lay their eggs, which, hatching, consume the host insect. So far, this wasp may be regarded as beneficial.

The family **Sapygidæ** is a small one, the members of which are usually found in the nests of bees. It has no economic importance.

The family **Pompilidæ** includes about a hundred and twenty species, and they are commonly known as the spider-wasps, on account of their habit of provisioning their nests with spiders, which they sting and reduce to a dormant condition. They are generally slender insects with long legs, and usually brilliantly colored and beautifully marked. While generally of moderate size, some of the species are very large, and here we find the well-known tarantula-hawk (*Pepsis formosa*).

The family **Sphecidæ** comprises the thin-waisted wasps, and includes the well-known mud-daubers. These are commonly known as the thread-waisted wasp, on account of the thin, thread-like process which connects the abdomen with the thorax, and which is composed of the first two segments of the abdomen. This family is a very conspicuous one and embraces about seventy species in the United States, most of them well known from their peculiar form and habits. They build their cells from mud, and stock them with spiders or caterpillars, after first depositing an egg in the bottom. When hatched, the young larva finds an abundance of preserved food awaiting it, and remains in the cell until it has passed through all the changes, when it emerges a perfect insect.

The family **Larridæ** is composed of moderate-sized insects, which frequent sandy locations.

The family **Bembecidæ** includes some of the larger forms of this order. They make their nests in burrows, which they excavate in sandy places, and store them with flies. The larger species attack cicadas, and one may often be seen carrying away a cicada larger than itself.

The families **Nyssonidæ** and **Philanthidæ** are two groups of insects having the same general characters and habits as the foregoing, but differing in points of structure and wing venation.

The families **Mimesidæ**, **Pemphredonidæ**, and **Crabronidæ** are rather borers than diggers, although classed with the digger-wasps. They usually burrow into the stems of pithy shrubs and form their nests therein. As in all the other members of this order, these nests are stored with the preserved remains of other insects, so that all may be classed as beneficial.

Superfamily **Vespina**. (True Wasps.)

The true wasps are included in three families, grouped together in the superfamily Vespina. Insects belonging to this superfamily are all winged, and when at rest fold their wings lengthwise like a fan. The legs are not suited for burrowing. It is in this superfamily that we find the paper-wasps and nest-builders.

The three families under this group are the **Masaridæ**, the **Eumenidæ**, and the **Vespidæ**. The first of these is a small family of no importance in this place.

The second is a family of solitary wasps, the members of which vary in their habits, some being builders and some burrowers. Some of them build nests of mud, while others bore tunnels into wood in order to provide for their young.

The third family is of more interest, as it includes the social wasps, the nest-builders, and paper-makers. It is here that we find our well-known friends, the yellowjackets. These belong to the genus *Vespa*, and most of our readers, especially those who live in or have been in the country, are very familiar with their appearance and not unfamiliar with their mode of defense. Their nests, which are sometimes attached to buildings, trees, or fences, are made of paper, and are very elaborate specimens of architecture. Being social insects they accomplish some great works, and it is no uncommon thing to find one of these nests as large as a water-bucket. Sometimes they make their nests underground, either excavating a hole for the purpose, or taking possession of one already formed.

Superfamily **Apina.** (Bees.)

We now come to the bees, the last and highest of the Hymenoptera. It is here that we find the greatest intelligence displayed in the insect world. No insect has been so thoroughly studied as the bee. Books and libraries have been written about bees, and the most wonderful stories told of their intelligence, which would seem to far exceed anything we can call instinct and to closely approach human reason. They present to us the highest known type of social life, and the most perfect form of government.

Bees have been placed under the superfamily Apina, which is divided into two families, the **Andrenidæ** and the **Apidæ**, or the short- and the long-tongued bees. The habits of members of the different families vary greatly. Some are solitary, making a nest for themselves, and storing it with honey and pollen. Others can live only in communities. Some are very small, one of the mining-bees measuring but from one hundredth to three hundredths of an inch in length.

So far as relates to agriculture, bees are beneficial. They are not parasitic, like some of the other families of the order, although there are some bees parasitic on others, but in their work of gathering honey they are one of the greatest agencies in nature in the fertilization of plants.

Many species of both families are troubled by parasitic or cuckoo bees. These build no nest for themselves, but look out for a nest of the mason, carpenter, or other bee. When she discovers one at work, she watches, and as fast as the cells are completed, lays an egg at the bottom. This egg hatches before the egg of the rightful owner, and the larva of the intruder proceeds to eat the provisions stored by the careful mother of the rightful owner, and finally consummates its evil work by eating the young of the nest-builder.

Of the social bees, including the honey-bee, little need be said here, as the subject is too great to be handled in a few pages, and our object is merely to draw attention to the science of entomology, not to enlarge upon it, and also to draw special attention to those families which are either directly beneficial or injurious to our orchards.

The foregoing will serve to give our readers some general idea of the important science of Entomology. As stated at the commencement, the work is not designed to be thorough in any respect, and pretends only to give an introduction to this great science. Those of our readers who wish to follow it to a greater extent are referred to the following works:

"Entomology for Beginners," by A. S. Packard; "American Insects," by Vernon L. Kellogg; "Manual for the Study of Insects," by John

